USES OF WASTE MATERIALS

ARTURO BRUTTINI

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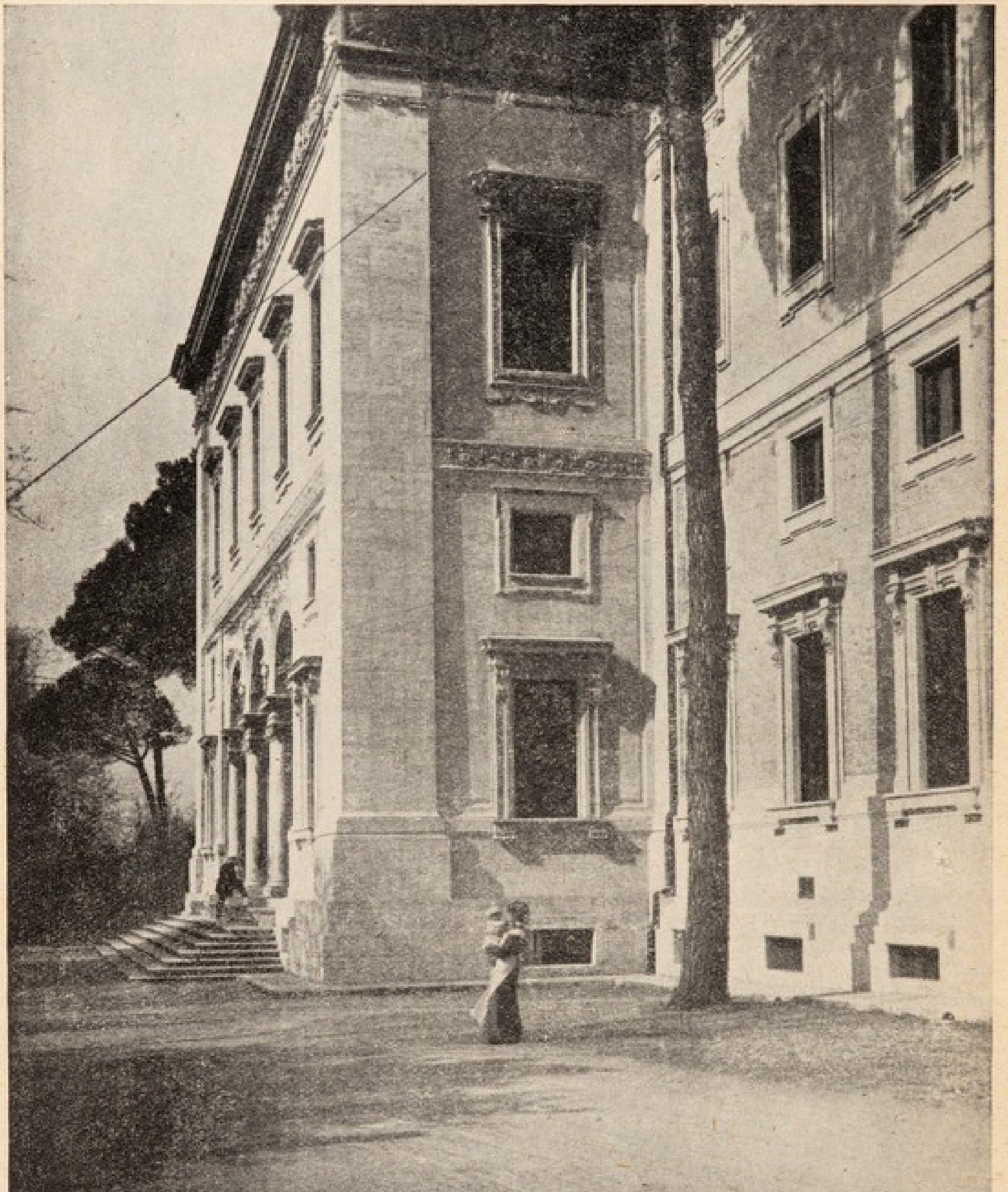

International Institute of Agriculture.

INTERNATIONAL INSTITUTE OF AGRICULTURE
ROME

USES
OF WASTE MATERIALS

THE COLLECTION OF WASTE MATERIALS AND THEIR USES FOR HUMAN AND ANIMAL FOOD, IN FERTILISERS, AND IN CERTAIN INDUSTRIES
1914-1922

BY
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WHIT 95 ILLUSTRATIONS AND DIAGRAMS

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PREFATORY NOTE

Among the subjects to be handled in the Enquiry into the "Intensification of Agricultural Production" set up by resolution of the Fifth General Assembly (1920) of the International Institute of Agriculture "regarding measures of every kind taken by the various countries during the War and since the cessation of hostilities to increase and render more intensive agricultural production" there appeared as the twelfth point the following:

"Measures taken to encourage the collection and conversion by manufacturing processes of waste material in view of their utilisation as food or feedingstuffs, in the manufacture of fertilisers . . . etc.".

This subject has been treated in detail in this monograph, which is emphatically the work of a technician for technicians, keeping as main objective the application of the various topics to agriculture and to the interests of farmers.

The publication of the French edition by the Institute has been followed by that of an Italian edition published, under the auspices of the Institute, by the firm of M. Hoepli of Milan.

The Italian edition contains a considerable number of additions, and the translation into English has been so arranged as to blend the two preceding editions into one. This English version, for this reason and also on account of later additions made during its preparation, is thus to be regarded as brought up to date in every respect and as being complete in form in comparison with the French edition, which had so favourable a reception in scientific and agricultural circles.

A. Bruttini.

International Institute of Agriculture
Rome, May 1923.

Pag.	Errata	Corrige
XVI	11. OLIVE HUSKS AND DREGS, p. 337	p. 237
XVII	29. "SUPERSOLFO", p. 292	p. 272

CONTENTS.

INTRODUCTION

The small yield of the ordinary crops, due to the reduced supply or complete lack of labour, to the scarcity of capital and shortage of fertilisers ; the re-appearance of malaria ; the damage done by water-courses no longer properly regulated ; the want or extreme scarcity of selected seeds ; the great difficulty of transport and communication ; the imperative necessity for provisioning armies and investing forces ; such were the causes that brought about during the War so serious a diminution in the supplies of food whether for man or live-stock on all markets, and in consequence made it necessary and even a matter of urgency to investigate local means of production and internal sources hitherto neglected.

It was thus inevitable that waste products and offals should be utilised and substitutes manufactured. Such substitutes might well have no element of the products they replaced beyond the name to which was added some epithet intended either to conceal or to indicate their origin. The waste products and offals whether of the manufacturing industries or of the food trades were turned to use : materials were utilised which had formerly been regarded as of no value from the point of view of human food ; and a further step was taken in bringing in raw materials which up to that time had never been used as food.

The purpose of this monograph is to show in detail all that has been done in the different countries during the War and also afterwards (1914-1922), along legislative, administrative and technical lines, as regards the utilisation of the by-products of industry, of offals and residues of all kinds, of raw materials up to then completely neglected, for the manufacture of products suitable for the food of man and live-stock and for the preparation of various fertilisers.

For many of these products no new process was involved, but merely bringing up to date and improvement of processes ; for others it was a question of fresh application of methods already known ; for others, on the contrary, entirely new processes, often ingenious ones, had to be employed.

It will appear that use was made of expedients devised on the spur of the moment, of processes adopted without precedent in the industry. But the eager quest of new methods or the bringing up to date of disused former methods has brought to light much of unsuspected value, as well as many ways of increasing the stocks of food, the fertilisers, and the raw materials of numerous agricultural industries, of future as well as of immediate importance.

As regards methods already familiar, we shall concern ourselves with them only so far as they present some new aspect of importance, not taken into account before 1914. It would be unnecessary, and also uninteresting, for example, to describe the application to the feeding of man and animals and to the fertilisation of the soil of the waste products of dairying, of milling of cereals, of the manufacture of vegetable oils, etc. It is not however proposed to omit all reference to these : and so to make the account more or less complete, a simple mention of these residues and offals will be made when necessary. The reader will thus find a comprehensive survey which will enable him to obtain the full information he may require, even if he refers only to the sources here quoted. For that reason pre-war publications are also quoted, where anyone anxious to acquaint himself with a subject in detail might usefully consult them.

No work as yet exists giving a description of all, nor even the principal products, dealt with in this monograph. There are, it is true, numerous publications on special points, and also on groups of products and by-products, but we have not succeeded in finding a work intended to make generally known, in the interest of the agriculturists of the world, the most important and noteworthy facts as to the utilisation of offals and residues, in particular during the time of the War.

By " the most important " is meant in special reference to the crisis which occasioned the invention or the application of a process, but it is not to be inferred that this importance need survive at the present time for all processes without distinction.

It is proposed to give an account not only of what has been done in the matter of utilisation of waste material to meet the difficult position, created by the shortage or absence of raw materials, but also what is being done now and what may be done in the future. All the investigations, the enquiries, the experiments, the manufacturing processes that made it possible for millions, during the war, to fight famine for themselves and their beasts, are not to be allowed to pass into oblivion !

There is, however, now no question of repeating all these processes because of any utility each one had at the time ; the point rather is to preserve and to repeat those that are of real economic value ; the remainder will pass into the past history of alimentation and of agricultural technique and will thus take a place in the wider subject of the War and its painful consequences.

The reader, then, will judge of the contents of this monograph, case by case : he will take into consideration the needs of agriculture in his own country, its resources both as regards food and feeding stuffs and manufactures, the supply of raw materials and methods of working them up, the state of international trade, etc., before judging whether it is worth while to give a trial to any particular product or, in certain cases, to improve the methods of manufacturing any product.

The subject of this book is undoubtedly only a part of the general survey of the sustained effort each country at war had to make, both during and after the hostilities, to meet the ever increasing scarcity of raw materials and industrial products indispensable to the normal life of society. It forms, however, no insignificant part of that survey, and one which if considered in its various aspects may afford some guidance for present and future action.

The utilisation by agriculture of waste material, as hitherto practised, has not always been conducted on sound technical and economic lines. The quantity of waste products that are lost through negligence or intentionally thrown away is still large, and in certain cases, very large. Manufacturing processes in use are often still so far not perfected that the raw material subjected to them only yields a part of its value : in fact, if 100 represents the potential utility value of any raw material used in manufactures or in foods, in conversion of these potential into real utilities, it frequently happens that not all the 100 units are utilized : a greater or less percentage remain still potential and are lost. This is not always a result of the intrinsic properties of the substance, but of defects in the methods of utilisation. If these losses were to be estimated even approximately, they would represent very large sums. The question is thus one that arises and its solution must be sought along the lines of most advantage to agriculture.

It must be recognized that there was a distinct improvement in this respect during the war when the scarcity or complete absence of certain raw materials, the difficulty or impossibility of transport, the great reduction in the supply of labour, the diminished production, etc. led the different peoples to find ways of turning to account waste material up to that time practically ignored, and wild plants, so far very little and merely locally used ; there were thus obtained, as we shall see later, immense quantities of food for men and for live-stock, fertilizers and other valuable substances, thus enabling the large populations to satisfy, at least in part, their food requirements and the needs of their agriculture.

But even in this time of exceptional stress, the utilisation of waste material was not complete, nor was it everywhere scientifically carried out, while on the other hand certain materials were then turned to account which could not be so treated now, on account of their high cost. It must not be supposed that any specific offal or residue can be utilised with advantage : this is possible with some of them no matter where they are produced ; but in the case of others, it is necessary to determine in each case by preliminary investigations and by careful experiment whether they are really worth utilising. For this reason it seem advisable and even essential that institutions for promoting progress in agriculture should include work of this kind in their programmes. As regards waste materials requiring no fresh investigation for their utilisation, it is enough to set on foot propaganda for the encouragement of their collection, preservation, manipulation and employment ; but for those the use of which is little known and which are thus either wholly or partially neglected, local enquiries and investigations are necessary, both on the technical and on the economic side, and as soon as it is clear that it would be worth while to make use of them, no means should be omitted of bringing them to the knowledge of agriculturists and of urging their application.

In this publication, which necessarily is of an international character, such investigations are out of the question. For this reason it has been thought better to refrain from making calculations of the costs of production, of manipulation, of transport and of application, etc., since the figures relating to these points would have a purely local value, *i. e.* only for the region to which they relate. The reader must make up for the absence of these figures by choosing the waste products which he thinks he could utilise and by applying to these the data resulting from his own practical experience and from his knowledge of local conditions.

Part II of this monograph consists of detailed descriptions of the origin, characteristics, properties, and principal methods of utilisation of such offals and residues as are of value to the farmer, a value sometimes remarkably high, sometimes only limited, but always worth taking into consideration, whether as likely to increase the stocks of food and feeding stuffs, or to supply the soil with a greater quantity of fertilising substances.

All kinds of waste materials even the less well-known, have been here brought together, so as to render the account as complete as possible, and perhaps instructive in view of future requirements.

It seems advisable to make some suggestions as to propaganda which governments and institutions for promoting agricultural progress should employ to disseminate among agriculturists information necessary to the utilisation of refuse. The problem of such utilisation may seem a small one, if each offal or residue be taken separately ; but it is not so when considered as a whole, *i. e.* when the aim is recognized as the employment for the feeding of men or live-stock, or for the fertilisation of the soil, of enormous quantities of substances which in many countries are still completely neglected or only in partial use.

Propaganda may be made effective in two ways : 1) by oral exposition, when possible accompanied by demonstration, addressed directly to agriculturists by suitable lecturers, such as departmental instructors, instructors of travelling schools of Agriculture and the like ; 2) by the circulation in country districts and among manufacturers of suitable leaflets, short, clear, practical, and well illustrated, of the type of the excellent *Bulletins* which the Ministry of Agriculture of the United States scatters in thousands among American agriculturists and sends also widely into other countries. Publications of this kind, based on facts verified by experiment and on a knowledge of the conditions of the particular branch of agriculture it is intended to stimulate, are always of great efficacy. It is obviously impossible to adopt for all countries alike one set form of presentation of the subject or even of printing, but there can be no difficulty in adapting the form to the special conditions of each nation.

For propaganda on this extensive scale the action of an international institution might be of great use and the International Institute of Agriculture should be particularly well qualified to undertake it. It could prepare and send out, on the request of the competent authorities of the adherent States, either a complete documentation on the given waste product or residue, or a practical memorandum of a general character, capable of adaptation by addition or modification to the special conditions of the given country, or on occasion both the documentation and the memorandum.

It is beyond doubt that if a more scientific and more intensive utilisation of waste material can be achieved, it will mean a saving of hundreds of million of francs to the resources of a large number of countries. The statistics reproduced in Part II of this monograph are proof of the accuracy of this statement.

The character and purpose of this publication has been made sufficiently clear in the preceding pages. If it succeeds in placing before agriculturists certain suggestions, technical information and data on the utilisation of the products; if it succeeds in rousing in them a wish to try to turn to account the raw materials or residues hitherto neglected or to improve the utilisation of other products already in use; if in other words, this work may form a modest contribution to the increase in the means by which men, animals and plants are nourished, it will have attained its aim and the International Institute of Agriculture will have added one more to the useful series of publications it spreads throughout the world.

PART I.

LEGISLATIVE AND ADMINISTRATIVE MEASURES FOR THE UTILISATION OF WASTE PRODUCTS AS FOOD AND FEEDING STUFFS, AS FERTILISERS, AND IN CERTAIN INDUSTRIES.

As regards the collection of refuse and waste products of all kinds, which could be used to a greater or less degree as food for man or livestock, or as fertiliser, etc., the different belligerent states issued a large number of enactments and decrees, and in some, as we shall see, an active propaganda was carried out in the form of leaflets, lectures, etc., to encourage the people at large to undertake this collection, and so to reduce as far as possible the consumption of food.

But though there was an active collection of certain waste products, because a good price was paid for them by manufacturers of substitutes, others and especially those that were very widely scattered, such as leaves and various forms of vegetable refuse, were not largely employed in many states. It was however a different matter in GERMANY, where, as will be shown later, a highly developed organisation of special Commissions was charged with the duty of arranging for the collection of every kind of waste product with a completeness far beyond that shown by any other of the belligerent states. The fact is readily explained by the influence exercised by the blockade from the beginning on the general economic situation of the German Empire and its allies.

The legislative and administrative measures dealt with in this section provide, as regards certain of the belligerent states, and especially those of Central Europe which were for so long subjected to the blockade, a vast amount of material from which it will be sufficient merely to select that which is most closely concerned with the subject for the sake of brevity and practicality.

This appears to be the best method to adopt inasmuch as many of these legislative and administrative measures are already obsolete, and are in any case inapplicable to present conditions. The names of the publications containing these measures will be given for the benefit of those who may require to make a more detailed study of the question. As also the majority of the processes described in Part II are the result of studies and experiments made by government departments, experimental institutions, societies, manufacturing firms and individuals, care has been taken to assign the credit to the proper quarter in each instance.

The necessity has not been overlooked for making a full historical documentation, such as to enable the reader to find in a single publication a full account of all the measures adopted. He will thus have the opportunity of estimating the importance of those that are of most interest to him, from the point of view of their practical application and possible improvements through the use of the readier working methods now available as a result of the better conditions of industry in general and of agriculture in particular.

Mention has already been made of the special conditions affecting the Central Empires in the matter of their food supply ; the reader will note that in the account to be given in the following pages the measures taken in Germany for the utilisation of refuse and waste products are far more important both as regards number and significance than any similar measures taken either by the Allies or by the United States.

As already stated, this difference is mainly due to the blockade : in fact while the Allied States could in spite of the submarine warfare readily exchange their products and obtain supplies from their colonies, from the Dominions and America, the Central States, hemmed in more closely every day by land and sea, were soon obliged to rely solely on their own native resources as regards raw materials for industries and agricultural products. And as before the war the importation of raw materials and of certain agricultural products was considerable, means had to be found, even when taking into account the reduced consumption due to rationing, for making good the absence of imports ; accordingly attention was specially directed to the possible utilisation of waste products and the manufacture of substitutes. The abundance and variety of substitutes surpassed all possible prewar conceptions. Hence Germany became " the country of substitutes ", and the German nation, as was abundantly shown during and after the war was indeed fortunate in that the end of the conflict saw too the end of certain substitutes made out of refuse that no one had ever thought of using in this connection and which it would have been better never to use at all.

But it must however be recognised that, speaking in general terms, these substitutes and the utilisation of refuse enabled the German people to prolong their resistance, though the substitutes were only one of the factors in this resistance and could not take the place of all the other factors which determined victory or defeat.

Before treating in detail cattle feed and fertilisers it seems desirable to make some general statements with regard to what was done in certain states in the way of studying the problem of the utilisation of refuse and waste products immediately after the outbreak of war.

In GERMANY the results of the blockade were at once anticipated, and a lecture and press propaganda was undertaken (particularly for the purpose of enlisting the services of the rural population in the securing of food supplies. This took the form of a wide distribution of printed matter to clergy and school-masters suggesting schemes for meetings and conferences in farmers' clubs, schools and churches (1).

(1) Cf. *Die Lebensmittelversorgung und die Mitarbeit der ländlichen Bevolkerung bei der Lebensmittelversorgung*. Vortragsstoff für Geistliche und Lehrer zu Vorträgen in Vereinen, land-

This propaganda was one of the first pieces of work undertaken by the *Kriegsernährungsamt* (War Food Commission) who took great pains to set out the most important considerations in food economy, with special regard to the points which experience showed to be ordinarily the subject of question and answers at lectures and meetings, and indicating the topics to which it was necessary for the lecturers to devote their special attention (1).

In the general plan followed in Germany from the outbreak of war, showing how with the frontiers closed food problems should be studied, recommendations were made to the effect that in addition to intensive methods of cultivation, a better use should be made of agricultural products, and orders in this sense were issued for all the States of the Empire. It was hoped in this way to emphasise at once the necessity for a systematic collection of refuse and waste products, and also of wild fruits (for making preserves, syrup etc.) (2).

In AUSTRIA where the means available were much more limited an attempt was made at once to carry out a plan for controlling the food supply of the people and of the live stock, on the analogy of the German plan, and hundreds of measures were passed in this sense, of which it is necessary here to give a chronological account (3).

In addition to the ordinary substitutes for wheat flour, experiments were made with very finely ground lucerne and clover hay flour, and this bread was free from any taste of hay. Several kind of moss were also used, and the utilisation of disintegrated straw was also proposed (4).

In the UNITED STATES the Bureau of Chemistry has in recent years made important investigations into the utilisation of the offals of certain agricultural products, and although in that country the shortage in food and feeding stuffs brought about by the war was immeasurably less than that experienced by the Central Powers, the Secretary for Agriculture even after the war pointed out (5) the immense importance of the processes by which certain perishable agricultural products can be transformed into material that can be kept and utilized as need arises. The United States thus felt the effects of the war even after it was over, while during the war certain kinds of refuse to be mentioned later (*e. g.* seaweeds), were widely employed.

wirtschaftlichen Vereinen, Gemeindeabenden, und sonstigen Gemeindeveranstaltungen in Schule und Kirche. Zusammengestellt von dem Leiter des Nachrichtendienstes des Kriegsernährungsamts Dr. Arno HOFFMEISTER. Leipzig, Spanner, no date.

(1) Cf. *Die Deutsche Ernährungswirtschaft im Kriege.* Vortragstoff Herausgeben vom Nachrichtendienst des Kriegsernährungsamts. Leipzig, Spanner, no date.

(2) Cf. ELTZBACHER P., *Die Deutsche Volksernährung und der englische Aushungerungsplan.* Brunswick, Vieweg u. Sohn, 1915.

(3) Cf. : 1) Dr. Ludwig von NORDECK ZU RATENAU, *Beiträge zur Kriegswirtschaft,* Die Kriegsernährungswirtschaft in Oesterreich. Parts 44-46. Berlin. 1918.

2) For the numerous measures taken in regard to milling of cereals and bread-making, the work of Dr. J. STOKLASA may be consulted, *Das Brot der Zukunft.* Jena, G. Fischer, 1917. — See also, BUNDESMINISTERIUM FÜR VOLKSERNÄHRUNG. *Das Oesterreichische Ernährung problem,* Part 1-3, Vienna, 1921-22.

(4) STOKLASA, op. cit., p. 95.

(5) Cf. *U. S. Dept. of Agric. Yearbook,* Washington, 1920, p. 50.

The numerous measures taken by the Allies will be conveniently detailed in the following chapters, dealing respectively with human food, feeding-stuff for live-stock, fertilisers and certain agricultural industries.

I. — HUMAN FOOD

There is a striking difference between the number of measures that were taken in GERMANY in respect of human food, and that of the measures instituted by the other States.

The Prussian War Minister (1) laid down the lines and undertook the direction of the vast organisation created for the collection not only of raw materials, but also of all kinds of offals and residues, an organisation into which, as a result of the co-operation of thousands of students and school-children, the whole nation was eventually drawn; thus was instituted the "Kriegsausschuss für Sammel and Helferdienst" (War Commission and Voluntary Service for collecting materials for utilisation), subsequently known as "S. A." (Sammelabteilung") (Department for collection of materials for utilisation), and an official was attached to each Command of the Army Victualling Service, whose business it was to report not only on army victualling but also on the food supply of the civil population, in so far as the interests of both coincided.

A special department of the Public Food Supply was constituted, whose business it was : 1. to treat with the military Staff authorities in regard to their intervention in the matter of the provisioning of the civil population ; 2. to keep itself informed of the state of feeling among civilians and of the general food situation ; 3. to represent the War Office on: all the other Ministries, Prussian as well as Imperial, the Federal Council, the Food Commission, the State Laboratories for Inspection of Food-stuffs, in fact on all bodies concerned with the food question, etc. For example when in 1916 the "Kriegsamt" (War Commissariat) was instituted, there was assigned to it among other functions that of "arranging for the distribution of meat and fat to munition-workers".

This National Food Department entrusted experts with the duty of examining the possibilities of increasing the production of fats by making better use of bones. The experts came the conclusion to that even in time of peace an insufficient use was made of bones, and that in time of war this use was even less satisfactory, because of the concerted action of persons influenced only by selfish desire for commercial gain. The voluntary organizations which had been set up in different parts of the Empire for the purpose of collecting all kinds of materials still available were threatened with extinction, in consequence of disagreement about methods of administration and of mis-

(1) Cf. PLOHN Robert, *Beiträge Kriegswirtschaft*, Part. 65. Das Sammelwesen in der Kriegswirtschaft. Berlin, 1919.

directed enthusiasm, and the large quantities of materials already collected remained stored unused in schools and public buildings. Hence on 29 March 1917 the War Commission and the Voluntary Service above mentioned were combined with the Prussian War Department, and the Chancellor revoked previous measures and gave orders that for the future the Food Commission should be responsible for the provision of food stuffs, and specially for meat and fat, including supplies for the munition-workers.

With a view to turning the work of the voluntary collectors to better account, the Food Commission arranged that all the Central authorities and the offices depending on them (in so far as they were not directly subordinate to the War Commission) should work in harmony with the organizations of voluntary collectors and should direct their efforts for the common ends. The first Food Commissioner BATOCKI, and also his successor von WALDOW, did all in their power to bring about a close co-operation between the efforts of the State Bureau and of the innumerable War societies and those of the Commission for the collection of material still available. The Ministry of Public Instruction of each of the Confederated States had effective support from the school managers and headmasters in inducing the scholars not to remit their efforts in collecting.

The collection and revival of the use of so many different materials hitherto neglected as unnecessary if not valueless began with the foraging excursions organized by the people of East Prussia who had suffered from the invasion of the Russian army. As these excursions became general, it resolved itself by degrees into a matter of collecting whatever came to hand. The Commission appointed to for direct this collection was defined in the monograph entitled "Denkschrift zur Sammlung von Abfallstoffen und Wild früchten", which was reprinted three times, as an Association for the collection of offals and wild fruits, a programme which later had to be simplified. But while the undertaking and its results grew in importance, there was an increase too, largely for lack of capital, in the difficulties to be overcome as to grading, warehousing, utilization and transport of the stuff collected and especially of the table refuse. The result was that in the spring of 1917 a certain further uniformity had to be introduced into this immense organisation of voluntary collectors of refuse, by the institution of local and district offices and committees of the War Offices and Offices for War Economy, as well as War Committees subordinate to the War Commissariat, which was itself, on 13 April 1917, placed in direct dependence on the War Service for Collection of Waste Material and of Voluntary Collectors.

If the collected matter was requisitioned by the State, it was sent to the Kriegsgesellschaften (War Associations); in any other case it was sold freely at the Government controlled price or at the prices agreed between the War Commissariat and the representatives of the dealers. A share in this work was also taken by the Imperial Association for concentrated foods, dried foods and wild fruits — the War Commissariat for vegetable and animal oils — the Commissariat for coffee, tea and substitutes — the Association for nettle cultivation — the Association for collection of beech leaves and mast (1).

The material collected was stored in special depots (Sammelgüter): the most important of these was the depot for the waste products that could be used directly or indirectly for food or feeding-stuffs, such as: wild fruits and plants — bone — seeds of forest trees and mast — horse-chestnuts — acorns — table refuse — coffee grounds — leaf-hay. The collection and utilisation of wild fruits and plants had been handed over by the Fruit and Vegetables Commissariat to a duly registered society, known as "Wildfrucht", which did some collecting on its own account, but was endeavouring to do so on the same lines as similar associations. The country was divided into districts in each one of which the organisation was directed by responsible experts in whom confidence was placed and who had to be members of the above mentioned society, the shares of which were sold at 50 *marks* with limited liability.

An essential point in the utilisation of wild plants and fruits was to ascertain if they were of direct use for food or could only be used in conjunction with food-stuffs proper to make them last longer, or if they were possible substituted for spices, tea, coffee, drugs, etc.

The Bulletins and Lists of prices published periodically by the above above-named society show in full the measures taken, the fruits utilised, and the prices obtained.

The Decree of the Federal Council relating to the trade in bones dated 15 February 1917 prescribed that anyone to whom delivery of 500 kilogrammes or over of bones had been made in the course of a week was obliged to make a declaration to that effect, every Saturday, to the War Commission for Oils and Fats. The basic price had been fixed at 10 *pfennig* the kg. In the first place the *fat* was extracted to be used for various technical purposes or to be refined for table use — the latter by methods so improved that a finely flavoured oil was obtained, irrespective of the quality of the raw material. The edible oil so obtained was used for the making of margarine: glue was then extracted from the bones as left, and finally they were ground and dried to make feeding stuff mixed with other ingredients. The industrial fat obtained from the bones was used in candle factories, where stearine, oleine and glycerine is extracted from it, as well as materials for the manufacture of soap and explosives. That is not all: with the bones soup and soup tablets were made which replaced meat extracts.

The fatty matter of bones is extracted either by steam in an autoclave, or by benzene.

The Oils and Fats Commission arranged for the extraction from the kernels of cherries, plums and apricots and the pips of lemons, oranges and pumpkins an oil called *fruitseed oil*; the residues from this

(1) Chapter II of the brochure of M. R. Plohn, already quoted, contains a comparison of the various methods devised for collecting these products, and a detailed and interesting description of the organisation of the school-children set to do the collecting.

manufacture were to some extent employed in making cattle-food. From 1 kg of seeds, an average of 50 grammes of oil as extracted, so that 4000 metric tons of seeds supplied, in 1916, 200 tons of oil: 10 *pfennig* was paid per kg. of seeds, that is as much as for 1 kg. of bones which supplied, according to quality, from 70 to 100 grammes of fat.

In making use of beech mast, experience already acquired was available; the Oils and Fats Commission did not begin on this till 30 July 1918. To induce a good number of people to collect them seeds and to deliver the full quantity collected, the State paid them 1.65 *Marks* the kg. (fixing 1.50 *Marks* for sales between private persons), left each person to collect as many as he pleased, and allowed the collector 60 grammes of table oil per kg. of mast delivered, at a price of of 90 to 95 *pfennig*. If the collector preferred to extract the oil on his own account, the State authorised him to have half the mast he delivered pressed, leaving the cake residue at its own disposal. Although the activity of the collectors was greatly interfered with by influenza, the revolution and bad weather, nearly 400,000 kg. of table oil were successfully obtained from beech mast, as well as a proportionate amount of fat and cake for live-stock.

The question of fats became more and more serious throughout the war in all the States, but in Germany it was of the first importance, and the efforts made there far outdistanced all that was done in the Allied States to secure for the people the necessary food fats. The following information, in addition to what has been said, may be of interest (1).

The total quantity of animal and vegetable oils and fats consumed yearly in Germany in time of peace was, in round figures, two million metric tons, including 400,000 tons of butter and about 1,100,000 tons of oil, lard, suet, tallow, crude margarine, *Kunstspeisefett* (a mixture of different fats) and margarine.

The principal oil-yielding crops of Germany in time of peace were spring and autumn rape or navette, linseed, poppy, hemp and camelina: they covered altogether nearly 125,000 acres, and produced 15,000 to 18,000 metric tons of oil. The slaughter-houses supplied 700,000 metric tons of fat and the utilisation of bones 15,000 tons. Not reckoning butter, of the remaining 1,500,000 metric tons of fats nearly half were of home production: the rest was imported, particularly in the form of oil-seeds, which were worked up in Germany.

In January 1915, the *Kriegsausschuss für pflanzliche und tierische Oele und Fette* (War Committee for Vegetable and Animal Oils and Fats) concerned itself with all the fats except butter and lard, which came within the scope of the *Zentral-Einkaufsgesellschaft* (Central Purchasing Society), which at the beginning of 1916 also undertook margarine, and then became transformed into the *Reichsstelle für Speisefette* (Imperial Office for Edible Oils).

(1) Cf. Ewald M., *Beiträge zur Kriegwirtschaft*: Die pflanzlichen und tierischen Oele und Fette ausschliesslich der Molkereiprodukte, in Frieden und Krieg. Berlin, 1918.

These organisations endeavoured to remedy the shortage of fats by the following means: prohibition of their use for certain purposes (as, for example, floor-wax), limitation for other purposes (burning, lubricating, etc.), requisition and rationing. The use of edible fats in industry was prohibited.

People were informed that for washing of clothes, etc. a *Waschpulver* (washing powder) might be employed, containing only 4 to 5 % of fatty acids, while for toilette soaps 20 % is necessary.

To encourage the growing of oil-yielding plants agriculturists were supplied with seeds and fertilisers at low prices, and a number of industrial and commercial facilities were granted to them. In this way an increase of 50 % in the production was obtained in 1916, as compared with 1915, and in 1917 an increase of 100 %.

In 1915, some experiments in the cultivation of the *sunflower* as an oil-yielding plant were made; in view of the good results obtainned, orders were issued in 1916 for the growing of sunflowers along the railway lines, but the scheme did not succeed, as this plant is not suited to the climate of Germany: hardly as much seed as had been sown was gathered. On the other hand, successful use was made of a number of home-grown oil-yielding plants, whose value in this way had so far been little recognised, especially orchard-trees, from which *fruit-stones* were collected and put to use from 1916 onwards.

If fruit-stones are crushed (shell and kernel together), and the oil extracted by pressure or by solvents, there is obtained: 1) a very small yield, as the shells retain part of the oil; 2) a non edible oil, because there is an admixture of the waxy substance which forms a thin covering of the inner skin of the shell; 3) the residue is of no use as feeding-stuff. But a means of separation was successfully found.

In 1916, chiefly owing to the activity of the schools and of women's patriotic organisations, 4000 metric tons of fruit-stones were collected which at the rate of an average yield of 5 % of oil gave 200 metric tons of edible oil, employed for the most part in the manufacture of margarine. Oils were made besides: from *pumpkin seeds* produced in Germany or bought in the Balkans and in Asia-Minor (10 % yield of oil), from *lemon and orange* pips, from grape seeds (the *Bundesratsverordnung* [decree of the Federal Council] of 3 August 1916 ordered the requisitioning of *grape residue* and the separation of the stones from it. In 1916 160 metric tons of oil were obtained from grape seeds); *beech-mast* (to encourage the collection of this, it was well paid and besides the collector obtained for every weight of mast delivered one tenth of the weight in oil; the shortage of labour however put a stop to the collection); *foxglove seeds, red pine seed, wall-flower seeds, cornfield weed-seeds*, the collection of which was organised in 1917.

The *Kriegsausschuss* ordered the removal of the germ from breadstuff cereals and extraction of oil from the germs. Before the war, the extraction of the oil of maize was almost unknown in Europe. It assumed importance in Germany, especially after the conquest of Rumania, whence came large supplies of maize. As time went on the technique of this extraction was improved, so as to obtain a yield of 1.5 to 2 % of the whole grain, and in consequence in 1917 several thousands of metric tons of oil could be obtained. Degermination of rye, wheat and barley was ordered also: the first yields 1 % of germs, the other two 0.5 % of germs, containing 10 % of oil. There is no difficulty about the separation of the germs in the milling; it was done in some mills even before the war and these germs were mixed with bran to make concentrated food of high value. In 1917, the German mills turned out every month 1500 metric tons of grain, from which 130 tons of oil were obtained. The residues contain respectively the following quantities of albumen: maize 10 % to 20 %; wheat 35 %; barley 40 %; rye 42 % to 43 %; and, besides, starch, sugar etc. They are used in the form of meal for soup and *Morgentrank* (morning beverage). The meal of maize germs is remarkably like pulse-meal in its composition and forms a good substitute for it, having nearly the same taste as pea flour. Taking all these oils together, Germany was able to equal and even to surpass the production of vegetable oils of the prewar period. With few exceptions, these oils were used in the manufacture of margarine.

As a result of the reduction of stock and scarcity of fodder, and the consequent impossibility of feeding the animals, the home production of animal fats was greatly reduced during the war. Attempts were made to remedy this by improving the methods of preparing internal fat, a process carried on in central model establishments. Germany was divided into 50 *Schmelzbezirke* (fat-rendering areas). The internal fats (leaf) of healthy animals yielded *Feintalg* (refined fat) and those of diseased animals or of carcasses *technische Talg* (industrial fat). Half of the refined fat was given up to the *Kriegsausschuss* which arranged for its transformation into margarine of superior quality. The residues of the refined fat (skirtings, greaves, scratchings) were made into sausages, known as *Griebenwürste* (greaves-sausages), while those of the industrial fat were used for cattle feeding-stuffs.

The preparation of pig fats was carried on under the same conditions as before the war, and no centralisation of this industry took place.

In conformity with a decree of the Federal Council of 13 April 1916, the utilisation of bones was taken over by the *Kriegsauschuss für Oele und Fette* (War Commission for Oils and Fats).

In time of peace there was no manufacture in Germany of edible *bone-fat*. When bones are boiled in a saucepan, about half their fat goes into the soup and the remainder is lost. It is however easy to extract the whole of the fat, *e. g.* by water vapour under pressure it can be obtained either from uncooked bones, or from bones from which soup has been made, provided that in either case they are fresh. Other by-products can be obtained from bones: soup cubes, gelatine, glue, feeding-stuff, fertiliser, raw material for the preparation of phosphorus (for munitions).

Before the war from 25 to 26 million *marks* worth of bones were lost to the German industry of bone-utilisation. A decree of the Federal Council of 13 April 1916 made it necessary to notify all large quantities of bones: burying of burning of them was forbidden; the quantity to be employed for food was restricted. These measures were amplified in May and in October 1916 consolidated and more stringent by the decree of 15 February 1917. The collection and delivery of bones to firms dealing with them was controlled by the communes who received 1 kg. of margarine for 100 kg. of bones delivered. For supplying bones the payment was 10 *pfennig* a kilo, and 18 *marks* for 100 kg. From May to December 1916, there was obtained, on an average, 30 metric tons a month of edible bone-fat; in the first months of 1917, 82 tons were obtained per month, and after that the quantity increased rapidly. This was partly due to the fact that, as the artificial preparation of glycerine for military use had been a success, a larger quantity of bone was available for food purposes. The sale of cows' feet in butchers shops was forbidden, as they were requisitioned for the preparation of neats' foot oil to be used as lubricating oil for submarines. A notification of 29 June 1916 made obligatory the manufacture of feeding-stuffs and of industrial fats from all animals or parts of animals rejected by the slaughter-houses as diseased, as well as from all carcases and slaughterhouse offals. This work was carried out under the auspices of the *Kriegsausschuss* in 1917 in 720 centres, 327 of which were built on a new pattern with thermo-chemical equipment. Cattle meals were made in these after extracting the fats. Numerous military installations were set up on the two fronts for the treatment of animal carcases by the same methods.

Fish offals and fish meals were likewise deprived of their fats before being given to cattle. Fats already used were made available again, being taken out of dirty water by means of apparatus known as *Fettfänger* (fat-catchers), 15,250 of which were sold by the *Kriegsausschuss* at the beginning of 1918.

Fats were obtained from: the residual liquor of textile factories — leather waste (130 metric tons in 1917) — fullers' earth (135 tons in 1915).

The following fat substitutes were prepared: as industrial oils, the mineral oils — as drying oils, pine-tree oil and coal-tar (produced by distillation of coal) — the natural resins as partial substitutes for soaps (lathering like soaps) — for toilette soaps clay and pipe-clay were used, plus 30 % of soap to 20 % of fatty acids, etc.

On the advice of the *Reichsfleischstelle* (Imperial Meat Office) of Germany, the local and provincial Meat Offices established during the war, *Zentralwurstereien* (central sausage factories and factories for the working up of meat). In these latter slaughter-house offals were worked up, with the minimum possible loss and with utilisation of all the viscera for manufacture of the sausages known as *Dauerwürste* (1).

Horse fat was also used as food. Edible fat was extracted both from fresh bones and from bones already cooked and collected from

(1) Cf. Dr. Krüger, Dr. Mayer, Dr. Niklas, Dr. von Ostertag, von Schlieben and Scholl, *Beiträge zur Kriegswirtschaft*: Vieh und Fleisch in der deutschen Kriegswirtschaft. Berlin, 1917.

houses, restaurants, war kitchens, etc. From these bones, industrial fats were also made, as well as cattle-meal and phosphatic fertilizers.

Kitchen refuse of all kinds was used for fattening pigs.

In the *Kadaver-Verwertungsanstalten und Abdeckereien* (establishments for utilisation of carcases) meals of great value as feeding stuffs were made.

Abfallfette (offal-fat) was obtained by washing the guts of cattle and sheep and removing the mucus from them.

In the establishments set up in 1915 in Belgium by the German military administration, the carcases were heated to 150° C. in an atmosphere saturated with water-vapour and were thus completely disintegrated and sterilised. Then the fat and the gelatinous substances in solution were separated. In the first year 1500 carcases were dealt with, and produced 366 metric tons of meat meal, 93 tons of bone-meal and 57 tons of fat. Meat meal is a good concentrated feed for cattle, containing 40 % of digestible albuminoids and 19 to 20 % of fat. Bone meal has been employed as an excellent fertiliser (1).

The guts, bladders and stomach linings were used in the preparation of cheap sausages. The scarcity of fat brought back into use certain old-fashioned recipes for extracting fat from pig-skin, especially in country districts (2).

As will be seen in Part II, the foods of vegetable origin also give scope for a utilisation of waste material, bread being an exception as will shortly appear.

In Germany (3), large quantities of jam were made with sugar, with fruits of inferior quality and with substitutes, such as beet-root, carrots, pumpkins, rhubarb fibre, elder-berries, tomatoes and also fruit-pulp treated in a special way.

The use of dried potatoes which had been general even before the war, especially for cattle-feeding, was still further increased during the war when they were utilised for bread-making (4).

Acorns were in particular used as a coffee substitute, after drying and roasting.

Horse chestnuts were reduced to a meal, or were used for making saponine and lactic acid, in which the salt known as "percaglycerine" was used instead of glycerine.

In 1918, 13 *marks* were paid for a hundred kilogrammes of fresh acorns, and 10 marks for the same quantity of horse chestnuts.

(1) Koller Dr. Th., Handbuch der rat. Verwert. von Abfallstoffen jeder Art. Wien u. Leipzig, A. Hartleben, 1921, p. 10.

(2) Cf. Dr. Goetz Briefs, M. Woss-Zietz, Dr. M. Stegemann-Runk, *Beiträge zur Kriegswirtschaft :* Die Hauswirtschaft im Kriege. Berlin, 1917, p. 59.

(3) Cf. Dr. Reichardt, *Beiträge zur Kriegswirtschaft*, Part, 28 : Die Kriegsmassnahmen zur Regelung des Verkerhrs mit Obst. Berlin, 1918.

(4) Those who wish to know what was done during the war in Germany for the drying of potatoes and utilisation of products thus obtained in breadmaking and food generally may consult : Dr. W. Lautenback, *Beiträge zur Kriegswirtschaft*, Parts 54-55 : Die Kartoffeltrocknung im Kriege. Berlin, 1919.

Large quantities of these were collected and sold to the official wholesale dealers.

The technical, economic and legislative measures taken as to distilling in Germany during the war are very numerous and of much interest ; but as they only partly concern the subject of waste material it is thought unnecessary to mention them here ; those interested may consult the publication of A. SKALWEIT entitled *Beiträge zur Kriegswirtschaft*, Branntweinwirtschaft und Volksernäherung, Berlin, 1918. Only the information in respect of the manufacture of *alcohol from residues* has been reproduced here, as follows :

When the scarcity of potatoes and cereals for distilling became noticeable, the use of molasses was permitted in 1915. But as during 1915-16, molasses had to be reserved as an ingredient in feeding-stuff, the use of artichokes, beet-root and beet root juice was again allowed.

By an Order of 22 March 1917 permission was given to distil, not sound potatoes, but frost-bitten, damaged tubers, or those in any way unfit for human food which would have been utilised for preparation of fecula or dried except for the circumstance that there were no factories for either purpose in the neighbourhood.

During 1916-17, nearly 250,000 metric tons of molasses were used in the distilleries, of which 86,000 tons were used in the manufacture of ferments.

Distilled molasses by itself does not produce lees that can be used as cattle feed, but this defect was obviated by adding such an amount of potatoes or beet-root as to make it so available.

From the season 1916-17 onwards, a new use was found for alcohol in Germany : the fatty acids obtained as by-products in the manufacture of fats for industrial purposes, when treated with alcohol, are converted into ethyl ethers, after which they are worked up into artificial edible fats (*Kunstspeisefette*). These digestible and not unpalatable ethers served to increase to a perceptible extent the very scanty provision of fats available in Germany.

A notification of 28 June 1917 gave special privileges to alcohol employed in this way.

The measures adopted in the invaded parts of BELGIUM were in many respects similar to those taken in Germany, partly because they were dictated by German authority, partly because in Belgium too, in spite of American assistance, there was a great shortage of food during the war (1).

As proof of the extent to which utilisation of waste material was carried in Belgium the following list is taken from the publication mentioned in the preceding note. It is a list of the by-products and offals obtained in milling the oats of the country (all such offals

(1) Cf. *Rapport général sur le fonctionnement et les opérations du Comité National de Secours et d'Alimentation*, Deuxième Partie, in *Le Département d'alimentation*, Vol. I. Bruxelles, Wromant et C.ie, 1921.

having commercial value during the war): sharps — thirds — pollards — feeding meal — bran — mill dust (fine quality) — black mill dust — oatmeal residues — hulls — shapes — straw — short straws — straw dust — husk — chaff — weed seeds — siftings — screenings — vetches — coarse vetches — barley screenings — peelings during drying — winnowings — sweepings — sievings — fine and coarse residues after cleaning bran — grit — wild oats — cleaning up residues.

Damaged cargoes such as wheat, rye, rice, beans and peas etc. were sent to the factories of DE BROUX, at Noirhat, for the manufacture of yeast, while the sweepings were often made over at a reduced price to various charitable institutions.

The waste from cleaning, husking and from manufacture of yeast with the above grains was made into feeding stuff.

For the manufacture of yeast for bread, a contract was made between the National Committee and the Yeast Manufacturers' Association, according to which all the alcohol produced had to be drained off, while the brewers' grains had to be sold to the usual customers at a price that must not exceed 3 francs the 100 kg.

In FRANCE (1) State intervention in the feeding of the nation meant as elsewhere the passing of a number of measures, but the record of these between 1914 and 11 November 1918 does not include any of importance on the collection and utilisation of waste material on lines similar to those adopted in Germany, with the following exceptions :

During the first weeks of the war, slaughtering for the French armies was carried on in buildings hastily adapted where it was impossible to utilise the offals, which were thus buried with the hides. The stabilisation of the line improved the situation in this respect (2).

In November 1914, General AZIBERT established behind the lines at Rheims a service called " Fat Manufacture Centre " the business of which was to collect in the slaughtering centres the internal fat (leaf) and cows'-feet and to convert them into utilisable matter, *e. g.* rendered down suet fat, to make edible fat, carriage grease, grease for leather, or for arms, etc.

(1) Cf. : 1) LEGENDRE R., *Alimentation et ravitaillement*. Paris, Masson et Cie, 1920, p. 237. — 2) MINISTÈRE DU RAVITAILLEMENT GÉNÉRAL, *Recueil des Lois, Décrets, Arrêtés, etc. intéressant le Ravitaillement de la France*, I-IV. Paris, 1917-1918. — 3) Those who desire obtain complete information on the problems of the food supplies for man and livestock in France during the war may with advantage consult the publications mentioned below which contain a very full series of analyses of all that was published in France on this subject. There seems however to be no mention of administrative or legal measures dealing with the utilisation of waste material. Part II will contain references to publications of a technical character relating to the feeding of live stock. The title of the publication in question is R. LEGENDRE, *Problèmes scientifiques d'alimentation en France pendant la guerre*, Comptes rendus des séances de la Commission d'Alimentation de la Société de Biologie, et Bibliographie analytique des travaux français publiés pendant la guerre (1914-1918). Masson et Cie, Paris, 1919.

(2) Cf. Ch. MOUREU, La Chimie et la Guerre. Masson et Cie, Paris, 1920, p. 136.

This service had to deal daily with 4 metric tons of fat and 3 tons of cows'-feet.

In 1916 the Minister of War decided that an organisation on similar lines should be created in each army.

In these Centres for the manufacture of fats, use was made of offals that would otherwise be thrown away and likely to be a danger to the health of the troops, if allowed to putrefy.

Studies were also made in the Laboratory of the Food Inspection Department of the extraction of oil from stones of apricots, peaches, cherries, etc. ; from acorns, grape seeds, coffee grounds, tomato and orange pips, etc. (1). The manufacture of grape seed oil and apricot-stone oil was industrialised and thus a considerable addition was ensured to the tonnage of supplies available for certain industries, in particular soap-making.

With the object of increasing the quantity of grape seeds collected the Government had a leaflet printed for circulation among vine-growers. As a matter of fact the quantity of oil lost each year in France by not using grape seeds is estimated at 15,000,000 kg.

The Government also took up the question of extraction of oil from maize germs. A factory was set up for this purpose at Villefranche-sur-Saône, where the extraction of grape-seed oil was also undertaken. This latter process was also carried on in works of private firms in the departments of Hérault and Var.

A decree of 10 September 1918 forbade the distillation of cider, perry, or lees until 15 December 1918, but a subsequent decree of 8 December 1918 prohibited the distillation of cider and perry, till 1 October 1919, but allowed that of pomace, on condition that a declaration was made by the proprietor of the quantity of cider, perry and pomace in his possession and of the number of persons maintained on his farm.

The quantity of pomace distilled might not exceed 10 % of that of the ciders and perries in store with the addition of one hectolitre per person maintained on the farm.

But a subsequent decree, of 25 February 1919, annulled the previous one and permitted " the immediate utilisation of material which might be lost if not used before the date fixed by the decree of 8 December 1918 " (2).

To encourage the collection of horse-chestnuts, mast and acorns, a Notice of the Ministry of Agriculture and Revictualling, of 19 September 1918 (3), stated that in 1917, 3000 tons of horse-chestnuts had been collected and used by the distilleries, adding that it was necessary in 1918 to collect not only horse-chestnuts, but also mast and acorns.

To save collectors trouble over consignment, the Committees for receiving cereals also took the horse-chestnuts, mast and acorns.

(1) Cf. Ch. Moureu, op. cit., p. 144.

(2) Rép. Franç., Min. de l'Agr. et du Ravit., *Recueil des lois, décrets, arrêtés, etc. intér. le ravit. de la France*, Vol. IV. Paris, 1919, p. 206. — Vol. V, 1919, p. 93.

(3) Recueil de lois etc. Vol. IV, p. 50.

Among the numerous wheat substitutes added to flour for bread-making in France, roasted groundnut cake meal may be mentioned, added in the proportion of 5 to 10 % (1).

A certain number of publications appeared in ENGLAND during the war dealing with food and feeding stuff on technical lines, but there seem to be none dealing especially with the utilisation of waste material for human food (2).

The system of collecting household refuse by volunteers adopted in Germany and carried out in particular by school-children would probably have been applied in England if the war had continued. In fact it was clear that decided advantages had already been gained by making trials of such collection in different localities, and it will be seen that the best results follow from a good system of collection.

"The municipalities have it in their power" writes H. J. SPOONER (3) "to render great service to the State by organising a complete system of collection of waste including house-to-house calls by voluntary women helpers". This work aims at the inculcation of the collection and utilisation of waste material, as well as of every kind of economy in consumption. The author goes on to say in the passage under quotation that volunteer committees might organise such collection, sorting, packing and transmission to main depots, which should be prepared by the district engineers and surveyors with properly equipped departments for different kinds of waste material, while arrangements would be made with the railway and canal companies for the use of otherwise "returned empty" trucks and barges for transport, or of space for dumping.

What has been said of the other Allied States may be taken as applying to ITALY, with the exception of the waste or rather the by-products resulting from the milling of cereals or from the manufacture of oil cake, such exception being due to the very fact that these are to be considered rather as by-products than as true waste material.

Substitutes. — The growing scarcity of the foodstuffs in all the belligerent States proved a stimulus to the ingenuity of a large number of experimentors, some however so wanting in scruple that substances actually harmful to the consumer were employed as substitutes. Fraud of this kind in fact flourished, in spite of the penal measures passed

(1) Cf. Ch. MOUREU, op. cit., p. 140.

(2) A full résumé of the subject of ordinary foods, during and after the war, is found in the work of E. W. SHANDAN, Animal Foodstuffs (London, G. Routledge 1920), on pages 310 and 319, under the title: « Some Effects of the War upon the Production and the Consumption of Animal Foodstuffs. — See also: 1) T. B. WOOD, *The National Food Supply in Peace and War*, Cambridge, University Press, 1917. — 2) T. B. WOOD and G. F. HOPKINS, *Food Economy in War Time*. Cambridge, University Press, 1915. — 3) M. H. REW *Food supplies in Peace and War*. London, Longmans, 1920.

(3) H. J. SPOONER, *Wealth from Waste*. London, Geo. Routledge and Sons, 1918, p. 21.

and the penalties frequently enforced. Desire for quick and large returns was strong enough to surmount all obstacles.

But this was not always the case : many substitutes were recognised to be not only good but even very valuable, and their use was not merely permitted but even urged by the authorities. It may be said that the manufacture of substitutes meant during the war an important contribution to the stocks of food and was instrumental in many parts in warding off famine. This fact was more or less marked everywhere ; but the greatest development of substitutes was in Germany, where special organisations were set up for their production and distribution. During this war Germany was called the " country of substitutes ". In fact in the case of many food stuffs only the name remained, while the substance was entirely different : this was notably so with tea and coffee.

There were in Germany Imperial Offices whose business it was to examine food substitutes and to grant authorisation for their sale. Some offices received only a few score applications, others dealt with up to 2000. Between the end of June and the beginning of August 1919, the number of applications rose from 11,496 to 13,329. Of these latter, 11,040 were approved unconditionally, temporary sanction was given to 149, and 2180 were rejected, though later on 197 of these were approved.

Waste material of all kinds was largely employed in the manufacture of substitutes.

Apart from the measures taken in all the States to permit or enforce the admixture with wheat flour for breadmaking of potato-flour, of pulse and of other substances containing starch or fecula not however to be regarded as waste material, the Order of 13 June 1917 in Germany may be mentioned : this allowed, in order to economise wheat flour the substitution of *Steinmehl* (vegetable ivory flour).

Coffee is a foodstuff for which there have always been a large number of more or less satisfactory substitutes, some replacing it completely, some merely admixtures. But during the war, the high price of coffee occasioned a still further increase in the substitute trade and when its importation was rendered impossible, as it was in the Central Empires by the blockade, the manufacture of substitutes reached an almost incredible pitch and the word " coffee " was the one most frequently employed by the inventors and manufacturers of substitutes (see p. 72). It is thus of interest to know that in Germany (1) there were before the war and when it began : 65 factories for making chicory and ground substitutes for coffee — 60 for making coffee from barley or rye malt — and about 100 smaller factories for roasting cereals (*Röstereien*) : in 1916 the whole number rose to 560, but in 1917-18, it fell to 124.

Some considerable part of these products were mixtures of chicory, dried and roasted beetroot, acorns, etc. There were also 20

(1) Cf. BÜRSTNER, Fritz, *Beiträge zur Kriegswirtschaft* : Die Kaffee. — Ersatzmittel vor und während der Kriegszeit. Berlin, 1918.

factories of "coffee essence" prepared with sweetened substances and 40 factories for fig coffee.

In many cases the substitutes too were adulterated by means of fruit stones, nut shells, etc. One factory even employed tannin in this way, till the fraud was discovered. The following were used in large quantities: grapestone cake — couch-grass — maize germs — oats husks — robinia seeds — potato pulp — residues of pressing fruit for cider or syrups — beetroot collars and leaves — small seeds — maize rachides — heather — etc. But such products had a disagreeable taste and were late drooped out.

"There is no material" says M. Burstner, "which has not been made into coffee substitute, from the wild radish to sawdust."

As to yield in coffee substitutes of the respective waste materials, the following may be quoted: dry malt (75 %) — dried beetroot pods (70 %) — the moist residues from pressing of fruits (17 %).

The same author has estimated at 131,000 metric tons the quantity of raw materials required to produce the coffee substitutes in use in Germany during a single year of the war (1917-18) and suggests obtaining this quantity by using the following quantities of the different materials employed:

Barley	44 800	tons.
Chicory roots cut up	16 900	»
Dried sugar beet	35 000	»
Acorns	3 000	»
Residues of dried grapes, asparagus and robinia seeds	3 000	»
Roasted hawthorn berries	300	»
Dried apple slices	10 000	»
Dried beet (not sugar)	18 000	»
Total	131 000	tons.

Among the numerous plants roasted during the war to make coffee substitutes, those that may be considered as on the whole suitable are those containing a good deal of sugar and starch, and also those that are powerful stimulants, and in addition those that contain poisonous substances as, for example, lupins, after the removal of such substances. Some substances that were quite unsuitable were however employed, such as sawdust, nutshells, and cabbage-turnips.

In Germany, the raw material for the making of coffee substitutes was distributed at the discretion of the National Food Ministry. With the exception of fig coffee and coffee essence for which there were special rules (in virtue of three ordinances of November 1917, December 1917, and August 1918), the price of these products was controlled, as was also that of acorn coffee in so far as it was not intended for pharmaceutical use. Mixing of coffee substitutes with a cereal or hop base with other coffee substitutes was only allowed by the authority of the Food Commission, and the same applied to tea. The admixture of real coffee with substitutes was forbidden. The peace time measure prohibiting the making of machinery for the purpose of manufacturing artificial coffee berries remained in force throughout the war. There was a further prohibition on any sale of these substitutes accompanied by statements that they were exempt from caffeine or that they contained " nutritive salts " or " salts restorative of the vital forces " or " physiological " or " hygienic " salts, thus describing the very small quantities of phosphate salts and other salts permitted by law. Notices had to be posted in the sale depots showing the name and the domicile of the manufacturers, even if it was a question of substitutes not made up in packets. The admixture of tea with medicinal plants was exempt from all control and restrictions, provided it was described as a medicine.

The chief manufacturing regions for substitutes were the two Saxonies, as well as the province of Brandenbourg, which includes Berlin. The Rhine provinces, Westphalia and Würtemberg, formed a group apart. In the other countries and provinces the proportion was much lower: 53 to 54 %, *i. e.* more than half of all the substitutes were made in Prussia.

Not reckoning the substitutes of essences and lemonades, Berlin produced by itself more substitutes than all the kingdom of Saxony, of that time, and Hamburg nearly as much as all Saxony. The speciality of the two Saxonies was *Backpulver* (baking powder), of Hanover the substitutes used for making puddings and sweet dishes, of which there was a large consumption. One quarter of all the substitutes for soup came from Prussian Saxony. Substitutes for spices were the speciality of Berlin first, then of Hamburg. Berlin manufactured 80 % of all the imitation sausages ; Hamburg 27,5 % of all the meat extracts and soup capsules ; the Rhine provinces manufactured 19,8 % of the coffee substitutes ; Hamburg was the foremost of the 19 States that manufactured tea substitutes, the " German teas ". 25,97 % of the imitation beer came from Bavaria, Prussian Saxony followed with 22,12 %, the Rhine provinces with 8,07 %, Westphalia with 7,02 % and Berlin with 2,46 %. Prussian Saxony manufactured one-fifth of the imitation liqueurs ; it also turned out nearly one-third of all the other substitutes of food stuff. Next came Berlin, Hamburg, Prussia and Silesia.

On the whole, application was made for the recognition of 12,900 food substitutes, and recognition was granted in the case of 10,625, subdivided into 87 groups as specified in the annexed Table, reproduced here as showing the great importance of substitutes in Germany during the war.

Authorisations granted for manufacture of substitutes in Germany.

Names of the substitute		Number of the definite concessions
Meat substitutes		29
Sausage substitute		837
Meat jellies and pastes		22
Meat soup cubes		34
Meat soup substitute cubes		120
Meat extracts		48
Concentrated extracts (vegetable and animal)		11
Condiments and pastes		199
Fish jellies and pastes		19
Fat substitutes		14
Milk substitutes		2
Cheese substitutes		1
Egg substitutes		33
Vegetable soups		849
Flour substitutes		2
Vegetables, kitchen herbs		28
Pudding powders		322
Table jellies		58
Flours for puddings		8
Fruit jams and jellies		47
Marzipan substitutes		108
Confectionery		13
Sweetmeats		13
Honey flavouring		19
Honey essence powder		32
Imitation honey powders, etc.		10
Coffee		511
German tea		190
Cocoa, chocolate		3
Beer substitutes		277
For beer substitutes	Basal substances	5
	Extracts	2
	Sweetening solutions	1
	Syrup	—
	Additional matter	2
Imitation fruit juice		73
Flavourings (fruit, etc.), aromatic essences and oils		254
Sweetening solutions		98
Lemonades		1535
Concentrated imitation lemonades		226
For the preparation of lemonades	Extracts	351
	Basal substances	954
	Essences	477
	Syrups	254
	Alcohol	21
	Ethers	26
	Acids	2
	Fixatives	10
Warm beverages		385
For preparation of punch and of warm beverages	Basal substances	182
	Flavourings	4
	Syrups	21

Authorisations granted for manufacture of substitutes in Germany.

Names of the substitute		Number of the definite concessions
For preparation of punch and of warm beverages	Essences	52
	Extracts	127
	Sweetening solutions	2
	Original substances	2
	Concentrated extracts	7
Beverages resembling liqueurs		449
For making beverages resembling liqueurs	Essences	81
	Extracts	7
	Basal substances	17
	Syrups	—
	Substitutes	2
	Oil mixture	3
	Concentrated extracts	—
	Flavourings	13
Beverages replacing wine		65
For beverages replacing wine	Essences	3
	Extracts	3
	Other substances	16
Saponine		4
Seltzer Water		40
Preservative		16
Condiments		84
Mixtures		38
Extracts		13
Essences		64
Aromas		176
Salts		34
Sugar		5
Powder		9
Leaf preparation		1
Oil of bitter almonds		4
Condiments for salad		29
Imitation vinegar		5
Baking powder		511
Colouring matters		14

II. — FEED FOR LIVESTOCK.

Special and extensive research on the question of livestock feeding was carried out in every State, but especially in GERMANY, where attempts were made to replace the most common feeds, which had become more and more scarce owing to the blockade and consumption by the army.

It may be stated that the research and experiments on this question made in Germany during the war equalled in number and scientific value, all the measures adopted in a minor degree in other countries, for though the need was great in all countries, it was greatest in those at war with the Allies.

From an official reply sent to the International Institute of Agriculture by Germany, as a result of the Enquiry of which this Monograph forms a part, the following statement is extracted (1):

The measures adopted to facilitate the collection and preparation of waste products with a view to rendering them fit for animal feed are contained in the following Regulations :

1. Bekanntmachung über die Verwertung von Speiseresten und Küchenabfällen (Notice as to the *utilisation of table refuse and kitchen waste*) of 26 June, 1916 (*Reichs-Gesetzblatt*, p. 593) and 8 January, 1919 (*Reichs-Gesetzblatt*, p. 17).

2. Bekanntmachung über die Verwertung von Tierkörpern und Schlachtabfällen (Notice as to the utilisation of carcases and slaughterhouse offal) of 29 June, 1916 (*Reichs-Gesetzblatt*, p. 631), modified by the Regulation of 17 August, 1917 (*Reichs-Gesetzblatt*, p. 715) and by the Regulation of 8 April, 1920 (*Reichs-Gesetzblatt*, p. 496).

3. Verordnung über Weinrester und Traubenkerne (Order regarding *wine lees* and *grape seeds*) of 3 August, 1916 (*Reichs-Gesetzblatt*, p. 1917), modified by an Order of 27 September, 1917 (*Reichs-Gesetzblatt*, p. 871).

4. Bekanntmachung betreffend Ausführungs bestimmung zur Verordnung über Weintrester und Traubenkerne (Notice regarding the mode of application of the Order concerning *wine lees* and *grape seeds*) of 3 August, 1916 (*Reichs-Gesetzblatt*, p. 887), and of 21 September, 1916 (*Reichs-Gesetzblatt*, p. 1073).

5. Verordnung über die Gewinnung von Laubheu und Futterreisig (Order on the production of *hay from the leaves of trees* and of *fodder from twigs*) of 27 December, 1917 (*Reichs-Gesetzblatt*, p. 1125).

6. Grundlegende Verordnung über Futtermittel (Fundamental Order regarding *Fodders*) of 10 January, 1918 (*Reichs-Gesetzblatt*, p. 23).

Orders 3 to 6 are now no longer inf orce. The Order of 8 April, 1920, on *complex feeds for livestock* to protect agriculture against adulteration (*Reichs-Gesetzblatt*, p. 491) and the rule for its application of 8 April, 1920 (*Reichs-Gesetzblatt*, p. 494) should also be noted (2).

The different methods adopted for utilising as livestock feeds animal and vegetable waste may be considered here. The technical methods of utilisation and the properties, composition, etc. of the products obtained, will be dealt with in Part II.

The "leather scrapings", *i. e.* the sticky, fatty layer removed from the skins when they are prepared for tanning was, in accordance

(1) Cf. FREIHERR VON FREYBERG, *Beiträge zur Kriegswirtschaft*, Part 59-60, Die Futtermittelwirtschaft im Kriege, Berlin, 1919.

(2) See also : Bestimmungen betreffend die Reichsmittelstelle, Geschäftsabteilung, Gesellschaft mit beschränkter Haftung. Bezugsvereinigung der deutschen Landwirte. Zusammengestellt vom Rechtsanwalt Dr. OTTE, Syndikus der Reichsfuttermittelstelle, Geschäftsabteilung, July 1918. Berlin Greve. — This work contains the decisions concerning the maximum and minimum prices of concentrated, feeds seeds, straw, hay and fodder substitutes.

with the Order of 24 February, 1916, no longer used except for making gelatine, glue and a livestock feed "which could be preserved for a long time", the quantity of which was fixed at 80 % of the total quantity under treatment. The War Commission obtained this glue at controlled prices, superintending its production, and reselling it at an increase of 5 %, if considered desirable, to cover expenses. The feed thus obtained was distributed like the other livestock feeds (Orders of 31 March, 1915, and 16 May, 1918). But the need of glue on the part of the army increased to such an extent that it was no longer possible to assign part of it for the production of livestock feeds.

The Order of 13 April, 1916, completed by that of 2 May, 1916, prohibited the burning, burying or destroying in any way the *bones of animals*, on condition, of course, that the local authorities provided for their removal. The collecting of bones was greatly facilitated by the joint action of collectors and traders; the supervision of the treatment of the bones was entrusted to the War Commission for Artificial Livestock Feeds, who were charged with the duty of subjecting the feed obtained, if necessary, to fresh treatment and of making suitable mixtures with other feeds; the price of the feed was fixed by the Chancellor. Oils and acids were subsequently included also in the above Order.

The Regulation regarding the execution of the Orders (16 February, 1917) prescribed that whole bones, as well as fragments and debris, not assigned by the War Bureau to manufacturers of articles made of bone, should, after the oil and fat had been extracted, be set aside by the War Bureau for artificial livestock feeds, while one part of the bones should be kept for making glue. The War Bureau and the War Commissariat for Oils and Fats together fixed the price of the oily substance extracted from the fresh bones and of the feed produced. In the declaration to the War Commissariat for Artificial Livestock Feeds of the quantity of feeds manufactured, their raw protein content, digestible protein and phosphoric anhydride contents had to be specified.

In order to obtain from *carcases* a larger quantity of machine oils than in peace time, and also for the manufacture of livestock feeds of animal origin, local authorities were invested with the power of limiting or suspending free trade in sinews and nerves.

The Order of 29 June, 1916, made it obligatory for public slaughterhouses which, in 1915, had slaughtered a minimum of 2,400 head of large cattle, to produce themselves, under the superintendence of the Commissariat (which could advise improvements in methods of working and also grant loans for perfecting installations), artificial livestock feeds and machine oils. Hides, horns, hoofs, claws, pigs' bristles and feathers were excepted. The products thus obtained (powdered animal waste and blood) became the property of the State, which employed them in the manufacture of livestock feeds; many carcases however had to be buried and were entirely wasted, on account of the lack of coal, means of transport and labour.

The Order of the Federal Council of 26 June, 1916, granted to communes of more than 40,000 inhabitants the power of obliging landlords to place in the yard or court of each house receptacles solely for table and kitchen refuse, which they were bound to have emptied three times a week.

A special Commissariat established at Berlin bought this refuse at a "fair" price and from it manufactured a "Milchkraftfutter" (concentrated milk feed), being under an obligation to supply the communes, on favourable terms, with a quantity of this feed proportionate to the quantity of refuse furnished by each commune.

By the Order (already quoted) of 3 August, 1916, *grape residues* and *grape seeds* became the monopoly of the Commissariat for Forage substitutes which arranged for the extraction of the oil from the seeds: these were then dried and ground for the manufacture of a "transportable feed" to be mixed with others of a better quality. The price of the residue had been fixed at 4.5 *marks* per 100 kg. fresh, and 2 *marks* after "piquette" had been made from it or after distillation.

The Order of 27 September, 1917, compelled distillery owners to keep all pressed residues for the War Commissariat and raised the price of fresh residues to 6.5 *marks* per 100 kg.; but the powder obtained was so low in nutritive value that it could not be mixed with other feeds, and the use of wine residues had to be given up.

Attempts were also made to use *horse-chestnuts* in place of the ordinary livestock feeds, but were unsuccessful, and they were used as substitutes for coffee.

On 8 November, 1915, the sale of *livestock feeds extracted from wood and straw* was placed under State control ánd their use restricted.

On 19 December of the same year, the following were also controlled: *vetch* and other *seeds* of legumes not used as human food — waste from the grinding of *beech-mast* — *castor-oil seeds* freed of their poisonous elements — *heather flour*.

The legislative and administrative measures for facilitating pig-breeding with a minimum consumption of the livestock feed which can be used for human food were very numerous in Germany (1).

Among the expedients used were: the extension of pasture in woods (under timber) — the gathering of beech-mast — the manufacture of meat-powder from slaughter-house offal and a "Künstliche Futterhefe" (forage yeast increased in an artificial medium — disintegrated straw and wood — ground heather — etc.) (see p. 92 and the following pp.).

For the collection of household refuse in Germany, measures were adopted which are worthy of a detailed description. Housekeepers were compelled to wash, dry and preserve fruit kernels for collection. Further, bones and food waste had to be kept in separate receptacles. In some towns, especially the smaller ones, housekeepers were obliged

(1) Cf. A. Skalweit and W. Klaas, *Beiträge zur Kriegswirtschaft*, Parts 20-21, Das Schwein in der Kriegsernährungswirtschaft. Berlin, 1917.

to carry the refuse to the collecting centre, but in the majority, a special collecting service was organised (1).

At first however some towns, and especially Essen, made extensive use of this refuse. To overcome a good deal of resistance, the commander-in-chief of the Mark of Brandenburg published an Order in January 1915, which made the collection of kitchen refuse obligatory also in Berlin, and the commander of Westphalia also adopted similar measures. As a result of these and similar orders, the forage requirements were reduced by about 2 million tons (2).

The value of the concentrated feeds made from table waste (3) corresponded to that of barley of medium quality. The German Imperial Company for the Manufacture of Concentrated Feeds paid from 1 *mark* 50. to 2 *marks* per ton for table refuse per truck load. When the communes supplying the refuse so desired, the Company delivered to them the extracted concentrated feed, so that the livestock in the various districts suffered no privation. The quantities of table refuse thus utilised were enormous: taking as an average 60 gm. per head per day, there would be a total production of 3,060,000 tons yearly, or 750,000 tons of concentrated feeds. The principal difficulties in the utilisation of this refuse were, on the one hand, its rapid decomposition, and on the other, transport, which is even more difficult in war than in peace time. The experience gained during the war, says the writer in a note, proves that in the future efforts should be made to effect further improvements in the utilisation of table refuse, which probably could only be attained by concentration, a plan which incidentally does not prevent the continuance of the practice of giving it when fresh to animals where this is customary. On the other hand by permitting owners of livestock to fetch the table refuse themselves, no advance is made towards the desired object, because the collection is not made with sufficient care and regularity. And when the refuse is in large quantities, the livestock owner does not trouble to collect it from every part of his districts, and the same is the case when there is an abundance of fresh forage, so that a considerable quantity of the refuse is wasted and swept away.

The Society for the Manufacture of Dry Forage made a start with the collection of coffee grounds, but this was soon given up, as they could not be used to advantage.

By order of 27 December, 1917, the War Commissary for Food Supplies granted to the competent local authorities the power to issue important orders regarding the collection of leaves to replace hay: and when the scarcity of army forage and especially of oats had, in 1918, increased to a serious degree, the military authorities established

(1) Cf. Dr. Goetz Briefs, M. Voss-Zietz and Dr. M. Siegemann Runk, *Beiträge zur Kriegswirtschaft*, Die Kauswirtschaft im Kriege, 1917.

(2) Cf. H. Schumacher, *Deutsche Volksernährung und Volksernährungspolitik im Kriege*, Berlin, C. Hegman, 1915.

(3) Cf. Freiherr von Freyberg, *Beiträge zur Kriegswirtschaft im Kriege*. Berlin, 1919.

a special Department for Replacing Hay by Leaves. The Minister of Agriculture and Forests had previously given instructions as to the extent to which owners of woods and forest rangers should allow leaves to be gathered. In each locality groups of pickers were formed. The head of the gang took charge of the collecting and the sales to the local representative appointed by the German Agriculturists' Federation. Generally speaking, only the young leaves of any species were to be gathered, with the exception of the black elder, cytisus etc. The leaves were simply pulled from the branches, or the branches were cut up to 1 cm. in thickness, tied into bundles, dried, and the leaves detached by shaking or beating. The green leaves were immediately taken out of the sacks and put in barns or other large sheds in layers of about 15 cm. deep, which were frequently turned to prevent mildew. On certain fixed days the harvest was sold to the local collector, who paid 4 *marks* per ton for green leaves and 10 for those dried in the open air. The collector had to look after the transport to the nearest railway station, to the drying-place or to the depots, for the sum of 50 *pfennig* per kilometre. The total price per ton of leaf-hay gathered 10 km. from the railway station was 16.50 *marks*.

The War Commissary for Forage Substitutes undertook to subject the leaves to the necessary treatment; the leaves, after drying, were reduced to a powder which, mixed with molasses, was made into cakes having a nutritive value 5 % higher than that of hay. The gathering of the leaves, begun towards the end of May 1918, was not to extend over the end of August, but, in view of the good results obtained, was prolonged. The Minister of Public Education pointed out its exceptional importance in a special Order and directed that whole classes of scholars were to be exempted from instruction in order to employ them in this work, even during the holidays. Thanks to the experience gained by the many War Societies previously instituted, the gathering of leaves began and continued on a really vast scale. The railways granted reduced fares to scholars taking part in the work. The Department for Replacing Hay by Leaves supplied sacks, rakes and presses for pressing the leaves. The harvesters were insured against accidents occurring during work. The result was so satisfactory that the Chief of the Department of Army Revictualling and the Chief of the War Commissariat publicly thanked all those who had taken part in this work. To strengthen the relations between the numerous groups of harvesters of objects so various, to keep them up to date in information, arouse their zeal and encourage the public more and more to take part in this work, the War Office published a bulletin showing the results obtained and decisions taken, and also had recourse to Wolff's Agency, to special publications, circulars and calendars intended especially for young people, to conferences with lime-light views, exhibitions, and even to the gramophone and cinematograph.

The registers instituted by the War Commission at the beginning of the War for the Collection of Utilisable Waste Material and for the Service of Voluntary Collectors, showed 6,109 local committees, not including those of the Grand Duchy of Baden, Würtemberg and

Bavaria, which had organised the same service independently of the Empire.

To replace forage, the lack of which became more and more disastrously evident, the State bought up at a generous price, at the same time regulating the trade, great quantities of vine tendrils, seaweeds, reeds (especially the paniculated kind): these did not find favour with livestock owners; lupin stems and mangold tops or sugar-beet collars of the 1917 and 1918 harvests cost at controlled State prices as much as straw, *i. e.* 80 *marcks* per ton.

An Order of 27 December, 1917, prohibited owners from felling trees or cutting off branches before the leaves had appeared, or even from entering the ground where they were growing. The military authorities mobilised the young people of the schools, who gathered enormous quantities of leaves and branches. The feed obtained by grinding and pressing the branches was intended to replace ordinary forage and partly also oats for the horses at the front. By the Order of the 11 May, 1918, all green leaves chopped, ground, etc., had to be reserved for the forage Commissariat. Disputes as to prices were settled by arbiters. But the excessively high price was only justified by the extreme necessity.

By grinding and chopping, a possible livestock feed was obtained from straw and the wild growth of pasture land and moorland (Order of 13 April, 1916). Attempts were also made to utilise couch grass as fodder, but the quantity of sand adhering to it and its very costly preparation prevented its being used.

The following table shows, in tons, the production by the War Commissariat for Forage and Artificial Livestock Feeds (a limited Company with share capital formed in September 1915):

	1916	1917	1918
	m. tons	m. tons	m. tons
1) Forage & livestock feeds with high albuminoid content	6 109	24 153	12 213
2) Forage with low albuminoid content	15 828	71 796	138 913
3) Do. mixed	44 716	101 641	141 800
Total	**66 653**	**197 590**	**282 926**

From the beginning of the War onwards, great hopes had been placed on *straw flour* (see p. 63).

Up to the publication dated 5 October, 1916, of the prohibition of sales of any kind of forage, except that produced on farms, cereal straw flour (dried and ground straw) was largely sold, generally under names which concealed the nature of the feed. Sometimes this flour also contained small quantities of green plants dried and ground, probably weeds. Later, straw flour was distributed to farmers through the "Bezugsvereinigungen" (co-operative societies for purchase and sale).

A "Bundesratsbestimmung" (Decision of the Federal Council) of 19 August, 1915, prohibited the sale in Germany of ground cocoa husks or food containing them, so as to prevent their use to adulterate human food, but a subsequent decision of 21 August, 1915, permitted their sale as livestock feed, mixed with finely ground straw or hay, or with wheat or buck-wheat husk.

For feeding *pond fish* (especially carp and tench) maize and lupin could no longer be used, as these had to be kept for human food, though it would have been better to have used them for pig-feeding.

As a substitute, a special *fish meal* was successfully manufactured from fish which could not be used for human food, the sort that are generally thrown back into the sea when the nets are drawn up. This powder was only slightly salted; it was impossible to use the ordinary fish meal made from fish heads and herring refuse because it is too salt. More of this fish feed was made by drying the shrimps that pass through the meshes used for separating those which can be used as human food. These shrimps, when given to fish of the salmon tribe give the flesh a pink colour much appreciated in certain districts.

The following were also used as fish feeds: *shellfish refuse, i. e.* what remains after the "flesh" has been taken, and *Graxenmehl, i. e.* the residue, dried or ground, of cod-liver oil extraction. At the request of the Westphalian Chamber of Agriculture, experiments were made in the use of *deposits from cream separators* in place of curds for fish-feeding.

Meal from slaughterhouse offal and carcases may sometimes be used as a fish feed, but generally its protein is not very digestible on account of the high temperatures used in its preparation.

With a view to the complete utilisation of *fish offals* and especially to the extraction of every particle of oil from fish livers and heads and from other offal used in preparing fish meal, the "Kriegsverwertung für Fischabfälle Gesellschaft mit beschränkter Haftung" was established at Altona. The fish meal was used for making a soup seasoning after boiling with concentrated hydrochloric acid, neutralising, then filtering, etc. For this reason the "Reichskommissär für Fischversorgung" (Imperial Commissary for the Fish Supply) did not authorise its use as a cattle feed but only as a feed for fish in fish-preserves.

By order of the "Reichskommissär für Fischversorgung" the heads of all herrings imported were to be removed and used for making fish meal or fish oil. At the end for the year 1917, after nine months of provisional trial, this ordinance came into full force. The annual importation from Norway into Germany of 100,000 barrels of herrings (of 100 kg. net weight) supplied 1,500,000 kg. of heads from which nearly 90,000 kg. of fish oil (train oil) and more than 400,000 kg. of fish meal was obtained.

The fish-meal waste after the oil had been extracted and the soup seasoning prepared from it and the waste from shrimps too small for ordinary table purposes but used in the preparation of the same seasoning were worked up as a cattle feed.

By the order of 15 February 1917 (*Reichs-Gesetzblatt*, p. 137), all preserved foods prepared, wholly or in part, from damaged animal matter, or in any way unfit for human consumption, had to be delivered to the " Kriegsausschuss für Oele und Fette " (War Committee for Oils and Fats) where they were turned to account for the production of fats.

At the end of 1917, the delivery of grain for poultry-feeding was altogether prohibited. As a substitute the " Geflügelbackfutter " was used, a feed prepared from mill refuse and bran (" Nachmehle "), and eventually from weed seeds and waste consigned by the Federal Food Office.

A substitute named " Avitin " was made, as to which no information is available (1).

Feed substitutes were also made by mixing molasses with excipients (" Träger ") formed from : chaff of all kinds, chopped straw, turnip-seed waste and chopped peat (2).

If during the War Germany was, as already said, the " country of substitutes ", which to a considerable extent, made up for the great lack of ordinary provisions it must be admitted nevertheless that in this case also, every medal has its reverse side, for there was much severe criticism of the substitutes in Germany, some of which was directed against the war food policy and the rationing.

For purposes of information, the following passage from a work by F. Hoff, a member of the Reichstag and of the Prussian Diet is reproduced (3) :

" Even in the Central Committee of the Reichstag we have had to listen to an address delivered by an official of the Imperial Ministry for the Interior, in the presence of Dr. Helferich, Government Representative, which would have realised the wildest dreams of the agrarians. The orator brought home to us the fact that by drying lees, grinding straw, weeds, carcases, fish, by working up food refuse, etc., we should be able, even during the war, and better still afterwards, to fill the gaps in our forage reserves. But the songster then became mute. A member of the Committee having asked Dr. Helferich whether this new branch of production was remunerative, the latter... had to reply " that the manufacture of the said substitutes is so costly that the question is bound to arise whether

(1) Cf. Von Bar, *Beitrage zur Kriegswirtschaft*, Part 49, Die kriegswirtschaftliche Regelung der Eierversorgung im Deutschen Reich unter besonderer Berücksichtigung der Organisation in Preussen. Berlin, 1918, p. 43.

(2) Cf. H. Schümacher, *Deutsche Volksernährung und Volksernährungspolitik im Kriege.* Berlin, C. Hegmann, 1915.

(3) Cf. F. Hoff, *Am Abgrund vorüber ! Die Volksernährung im Kriege.* Berlin, G. Reiner, 1919.

once the war is over, their preparation should be continued; the highly vaunted drying of lees, especially, is so costly, that in certain exceptional cases they might perhaps be used as a feed for sick animals, but never for livestock as a whole."

"The importance of the utilisation of table refuse and that of wild plants (*e. g.*, thistles) has been greatly exaggerated.

"Many draught animals in the towns and in the country have died from inanition, the official ration given them being quite insufficient to sustain them. The situation was somewhat ameliorated when establishments for treating straw were set up, which gave good results everywhere.

"Regarding the exploitation of pasturage, on which the President of the Imperial Commissariat for Food Supplies bases his whole stock breeding policy, it should be remembered that Germany only possesses in all 6,500,000 acres of pasture and cattle enclosures which, under the most favourable circumstances, would not suffice to sustain about 7 million head of livestock for more than 5 or 6 months."

As a guarantee against fraud, rules were drawn up in Germany to fix the minimum and maximum proportions of useful or noxious substances that livestock feeds put on the market might contain (1).

According to a Notice dated 21 February 1917, the "Bezugsvereinigung der deutschen Landwirte" (German Farmers' Trading Association) had to guarantee that the livestock feeds it distributed, besides being up to average standard, had constituents as follows:

Cereal waste: maximum 1 % of sand.
Oat bran: maximum 25 % of raw cellulose.
Wet potato pulp: at least 15 % of dry matter.
Meat meal or carcass meal: at least 55 % of protein and fatty matter: maximum 27 % ash.
Herring meal: at least 55 % protein and fatty matter.
Fish meal: at least 55 % protein.
Ground dry blood: at least 13 % nitrogen.
Bone gelatine: at least 45 % protein.
Leaves, root ends and beet tops, dried: maximum 1 % sand.
Dry fruit pulp: at least 88 % of dry matter, maximum 2 % of soil sand.
Ground clover hay: no residue on 3 mm. sieves, maximum 2 % soil or sand.
Straw flour: maximum 2 % soil or sand.
"*Eiweiss strohkraftfutter*" (see p. 92): 15 % sugar — 60 % of straw dry matter — maximum 14 % water.
Common reed flour: maximum 10 % water (15 % in chopped, but not ground, reeds) — maximum 2 % sand.

(1) Cf. KLING, Dr. MAX, *Die Kriegsfuttermittel*, Stuttgart, E. Ulmer, 1918, pp. 7-8. *N. B.* — This author describes in this book his own researches and those of other experimenters. A bibliography is attached to each chapter and the numerous references to this work that follow are to be understood as indicating that the relevant bibliography may there be found. (*A. B.*).

Meat meal: at least 76 % raw protein and fatty matter — maximum 11 % water.
Mussel meal: at least 9 % raw protein — maximum 7 % water, 3 % sand and 3 % salt.
Grape residue powder: at least 12 % raw protein and fatty matter — maximum 12 % water and 3 % sand.

The measures adopted by the Government in AUSTRIA for the supply of livestock feeds were numerous, and, like those regarding human food, copied to some extent similar measures adopted in Germany.

The following information is taken from a special Report sent to the International Institute of Agriculture by Dr. HERMANN KALLBRUNNER and entitled: "Measures adopted by the Austrian Government during the War (1914-1918)."

The great variety of livestock feeds was due to some extent to the stoppage of brewing and of the distilleries, releasing respectively malt and dried grain, and distillery residues.

The measures taken to make good the scarcity were numerous, but had not the desired results, for livestock feeding became more and more difficult.

An Order of 8 May 1915, No. 58, establised the State control of brans.

Molasses was reserved for the production of alcohol and thus could not be employed in livestock feeding. The yeast used in brewing, dried and deprived of its bitter flavour, was used but the quantities available were very limited and continued to decrease.

More use was made than in the past of the blood of slaughtered animals.

The Government carried on excellent propaganda for the utilisation of kitchen refuse, but it was impossible to obtain it fresh and utilisable for poultry feeding, so that the attempt had to be abandoned. Nor did they succeed in getting it dried in the home, with heating apparatus, as advised.

The "Futtermittelzentrale" (Central Feedingstuffs Office) was entrusted with the duty of requisitioning and distributing all kinds of forage, and this control was also extended to the different oil cakes. This Office also had to distribute one quarter of the molasses waste, sugar-beet cultivators and milch cow breeders having the preference.

Propaganda regarding forage substitutes was carried on by the Government organs of the press, and their preparation was facilitated, especially in the State forests.

In the third year of the War, the scarcity of waste for concentrated feeds was still more strongly felt.

Powdered cockchafers, the rhizomes of rushes ground, and even heather, as molasses excipients, were used in this connection. The Government also tried to utilise nettle waste from nettles used in manufacturing materials to replace cotton, as well as slaughterhouse and carcass offal, dried and ground to powder. Unfortunately, the necessary coal was lacking.

During the war, the farmers used bone meal more and more for poultry and pigs, but the low prices rendered its collection difficult.

An order of 28 September 1918, No. 330, directed that horse-chestnuts be gathered by the joint efforts of school-masters and their scholars. Collecting centres were thus established, which also had the duty of collecting other wild fruits.

A special technical Committee was formed to examine new feeds.

An Order of 11 October 1916, No. 349, compelled all sugar refineries to dry all beet pulp and deliver to the Feedingstuffs Office which had to consign it subsequently to the producers.

On 1 May 1917 a "Ersatzfuttermittelabteilung" (Department for Feedingstuffs Substitutes) was instituted, which placed on the market various feeds prepared from waste products. Olive residues after extraction of the oil were used as livestock feed.

Attempts were made on a large scale to utilise the nutritive and digestive principles of straw by treating it with soda under pressure (see p. 92).

The Central Feedings tuffs Office experimented with many forage plants recommended as new.

It may also be useful to give some information on the use made to waste and residues as livestock feeds, during the War, in Bohemia. This information is taken from two reports by Prof. R. TRNKA at the Academy of Agriculture at Táboř (1). The materials used were: slaughterhouse offals, tanning refuse, potato tops, asparagus tops, rhubarb leaves, ground wheat and pea straw, maize stalks, ground heather twigs, ground beet seed, brewers grains, broad-bean pods, olive husks, peat mixed with 80 % of molasses, crushed grape seeds, almond kernels and plum stones, apple residues and mill dust.

The ALLIED STATES instituted a *Commission Scientifique du Ravitaillement* (Scientific Provisioning Commission) with the task of examining the question of human food and livestock feeding (2) both from the physiological and statistical standpoints.

As regards food for livestock, this Commission examined the quantities available, during the last three years of the War, in France, Italy and the United Kingdom, and drew up the following table.

In determining the quantity and nature of concentrated feeds necessary for livestock in the countries of the Allies for the agricultural year 1918-1919, the Commission included wheat offals, rice husks, brewery and sugar refinery residues etc., among these feeds.

(1) Dr. Prof. TRNKA, *Válečná krmiva. — Casová krmiva ahnojiva válečná*. Hospodařsko, Chemického vyzkumného ustavu při král České Hospodářské Akademii v Táboře. Řada II. Čislo 14-15. V Praze, 1918.

(2) Cf. *Commission Scientifique du Ravitaillement*, General Report: Food Resources and Needs of the Allied Countries, 2nd Report. Rome, Dec. 1918.

Available quantities of waste for Livestock feeding.

France — 1918-1919 — Production & Importation

Wheat and mestlin bran and refuse ("impuretés")	1,231,500	tons
Rye bran, and refuse	247,710	»
Barley » »	97,285	»
Maize » »	97,285	»
Brewery and distillery residues	100,000	»
Molasses	9,000	»
Beet pulp from sugar refineries	500,000	»
Grape residues	700,000	»
Apple and pear residues	200,000	»
Skimmed milk	685,000	»

Italy — 1917-1918

Rice husks	17,200	tons
Maize leaves and stalks	3,784,000	»
Sugar refinery and brewery residues	300,000	» (1916-17)
Grape residues	240,000	» (» »)
Skimmed milk	10,000	» (» »)

United Kingdom — 1918-1919

Molasses, and feeds treated with molasses	10,000	tons
Rice flour and refuse	10,000	»
Malt from breweries and distilleries	130,000	»
Factory waste	10,000	»

In Belgium (1) the scarcity of animal feeds increased side by side with that of human food, partly on account of German requisitions, so that the Belgian farmers had a very hard struggle to keep the livestock which they still had alive.

In connection with livestock feed, the German representative, in a reply to the Central Crops Commission, suggested replacing the shortage of bran by using different vegetable feeds, and also recommended the substitution of "carcass powder" for meat powder, and the utilisation of the household and market refuse which is generally thrown into the dustbin.

When the importation of livestock feeds, including distillery, brewery, sugar refinery and mill residues, etc., was stopped, the Agricultural Department asked for a reduced rate for the transport by rail of fresh pulp from sugar refineries. This was granted.

Among the industrial by-products used for feeding cattle and horses, molasses took an important place in 1915, and the manufac-

(1) Cf. *Rapport spécial sur le fonctionnement et les opérations de la Section Agricole du Comité National de Secours et d'Alimentation.* « Section Agricole », 1914-1919. Brussels, 1920.

turers undertook to supply Belgian farmers with four fifths of the molasses produced by them in the year 1914-1915.

In September 1916, the Central Oils Commission allowed the Agricultural Department to distribute among its provincial districts the meat meal coming from knackers' yards, viz., 20,000 kg. in 1916, 76,000 in 1917 and 427,000 in 1918.

The German district authorities had prohibited the use of straw as litter, but on a protest being made, the Governor General authorised the use of straw offal for sick animals and those with young or in milk.

In addition to the feeds distributed by the Agricultural Section, the provincial Relief and Food Committees took over the distribution of the by-products from flour mills and maize-mills, but only a small percentage of the live-stock could benefit from these. This contribution was further greatly reduced when the bread famine necessitated the grinding of whole meal, there being thus no production of bran.

At Louvain (close to the establishment where maize was treated for its products and by-products) a large swine-fattening undertaking, afterwards completed by pig-breeding and rearing pens, was set up. These took the maize by-products at very little above cost price (1).

The Committee for the North of France, on receiving damaged herrings from Rotterdam, had a livestock feed made from them by the factories at Remy.

The same Committee handed over to the National Belgian Committee a livestock feed made from damaged cocoa. A similar feed was produced by the factories at Remy and contained : 15 % of damaged cocoa, 40 % of ground " kafs " (chaff), 30 % of bran and 15 % of pollards. In the course of the first half of the year 1918, the factories at Remy produced 10,130 kg. of livestock feed from 1,794 kg. of damaged cocoa.

Although the position in FRANCE as to supplies was much better than in the Central Empires, the question of the use of waste matter, especially for livestock feeding, was attentively examined by the Government. After consultation with the Director of the School of Veterinary Surgery at Alfort, the authorities issued a circular (2) addressed to the Prefects, dated 18 July 1917, containing a " Note sur l'Alimentation du Bétail en période déficitaire » (Observations on Livestock Feeding in times of scarcity). The Note shewed that at that time many food stuffs little utilised, or entirely neglected, might serve for the feeding of domestic animals. These food stuffs are: pulse unfit for human food — rice and other residues — grape and

(1) Cf. *Rapport général sur le fonctionnement et les opérations du Comité National de Secours et d'Alimentation*. Deuxième Partie. « Le Département d'Alimentation ». Vol. I. Brussels, Froment et Cie, 1921.

(2) Cf. MINISTÈRE DU RAVITAILLEMENT GÉNÉRAL, *Recueil des Lois, Décrets, Arrêtés, Circulaires, Rapports, Documents intéressant le Ravitaillement de la France*, Vol. I. Paris, Impr. Nat. 1917, p. 318.

apple residues — heather — broom — mistletoe — the leaves and twigs of trees — vine leaves and tendrils — gourds — etc. For swine feeding, reeds might be turned to account.

Use could also be made of tanning refuse, fish meal, and the contents of the paunch of slaughtered oxen. Horse-chestnuts and acorns could also be brought into general use ; the former are more especially adapted for sheep ; cattle also consume them, but the results are less satisfactory from an economical point of view. They may also be given to horses. Swine invariably refuse them, and they are poisonous in the case of fowls, ducks and geese.

" Undoubtedly considerable quantities of really useful foodstuffs are not used at all, or not rightly used. Certain feeds, known in some Departments, are unknown in others. It is therefore of great advantage, economically, to diffuse practical knowledge on this question among stock breeders and owners generally. "

In spite of the concise but very useful contents of this Circular, the question of livestock feeds ought, according to some writers (1), to be examined also from the physiological point of view, so as to obtain information on the systematic and economical use of livestock feeding stuffs. For instance, M. LEGENDRE, Secretary of the Commission d'Alimentation de la Société de Biologie (Food Commission of the Biological Society), after dealing with the scarcity of livestock feeds and the utilisation of numerous substitutes, says : " There is above all no pratical knowledge of the physiological aspect of livestock feeding, a question which has not yet been formulated in France, in spite of its great economic importance, and all that is available are the insufficient data furnished by some experts, supplemented by some practical information collected on a farm by GOUIN and ANDOUARD. This problem of the *scientific* feeding of farm stock is one of those which require the most urgent attention to-day. "

To remedy the scarcity of forage, the " Intendance " introduced forage mixed with molasses as a horse feed (as part of the ration for horses), and, for that purpose molasses were requisitioned and priced according to their sugar content (2).

Finally it was ordered, by a decree of 24 September, 1919, relating to cereals unfit for milling, flour unfit for making bread and to short weights of grain or flour in the mills and bakeries, with a view to checking certain regrettable practices which had come to light, that the following could not be sold without the authorisation of the " permanent cereal bureaux " : cereals which had become unfit for grinding, cereal residues and flours which had become unfit for breadmaking as well as the offals from these flours.

Persons taking such produce had to undertake to use it for feeding their stock or for industrial purposes without rights of disposal to others (3).

(1) Cf. R. LEGENDRE, *Alimentation, Ravitaillement*. Masson, Paris, 1920, p. 300.
(2) Cf. MOUREAU, op. cit., p. 145.
(3) *Recueil des lois*, etc. Vol. VI, 1920, p. 88.

In Italy, in spite of the scarcity of forage, no special measures were taken to collect and utilise waste, in the way adopted especially in Germany, except in the case of olive residues. A Lieutenancy Decree dated 2 September, 1917, No. 1479 (1), forbade the use as fuel of olive residues not treated with solvents, and afterwards ordered the residues after thorough treatment to be placed at the disposal of the National Fuel Commission, which had to allocate them for use as fuel. Regarding the possibility of using such exhausted residues as a livestock feed, the Decree says nothing.

In conclusion, Italy did not feel the absolute necessity of having recourse to residues or other matters not classed as ordinary livestock feeds, other than the common use made of the residues left from the grinding of cereals and from the extraction of oil from grain, because, even during the War, the farmers were able in spite of the great scarcity of labour to produce at least the absolutely necessary feed for livestock.

This was also the case in the other countries of the Entente, which explains the great difference, both as to number and nature, between the measures adopted by these States and those taken by the Central Empires, especially Germany.

In the United Kingdom, which, in spite of the action of the German submarines, could continue to get supplies from the Dominions and Colonies, little need was felt for recourse to waste products for food in general so that British special legislation (2) includes no particular measures other than those concerning the use of cereals, of their by-products and of the ordinary food. Great activity, on the other hand, was shown in the matter of fertilisers, to be described.

An important Order dated 27 Sept., 1918, bore direct reference to the collection and utilisation of waste and refuse, and laid down the following general rules (3):

The Army Council, in concurrence with the Admiralty, the Ministry of Munitions, the Board of Trade, the Board of Agriculture and Fisheries, the Food Controller and the Local Government Board, has full powers to regulate, prohibit, and give directions relating to the collection, destruction, disposal, sale, purchase, delivery or storage of waste as defined for the purpose of the order, and may confer on any local authority such powers as appear necessary for the purpose of giving effect to the order.

The local authorities could also be authorised, upon their own application, in any case where refuse was collected by the authority, to utilise any such waste for any purpose judged suitable.

(1) Cf. *Raccolta Ufficiale delle Leggi e dei Decreti del Regno d'Italia* per gli anni 1914-1920. Rome, Tipografia delle Mantellate.

(2) Cf.: 1) Manual of Emergency Legislation. Defence of the Realm Manual, Sept. 30, 1919. London, H. M. Stationery Office. — 2) Supplement to the Manual of Emergency Legislation. London, H. M. Stationery Office, 1914-1915.

(3) Manual of Emergency Legislation. Defence of the Realm Manual, 8th Ed., Sept. 30, 1919. London, 1919, p. 48.

There was finally to be a definition of the material that for the purposes of the regulation was to be regarded as waste.

Penalties were enacted against those who should not have observed the measures and carried out the orders relating thereto. Special conditions were indicated for the application of the Act in Scotland and Ireland.

The British Military Authorities (1), during the War, obtained good results from the utilisation of waste products of the field food factories, the total receipts amounting to £ 700,000. It may be estimated that from this utilisation about 13,000 tons of suet were obtained, yielding 1,300 tons of glycerine, valued at £ 312,650.

The factories working for the French Military Authorities supplied 500 tons of glycerine.

Other sources of profit were the sale of horse-hides and bread-crusts, the utilisation of bones, etc.

In 1917 the British Military Authorities realised £ 5,626,000 from the utilisation and sale of all the waste products.

In spite of the great production of animal and vegetable foods and forage in the UNITED STATES of which a large part was destined to supply the Allies during the War, the food consumption was controlled and a special administration for this work was created under the name of "Food Office".

A special department of this Office (2), known as the "Garbage Utilisation Section", gave particular attention to the collection of household refuse, especially in the large towns. Owing to the activities of this section in 1918, in 40 towns, with a total population of 2,217,000 inhabitants, the household refuse, which had previously been wasted, was utilised as swine-feed ; in addition, 3 towns now have an installation for extracting the fats from this refuse and converting it into fertiliser.

The monthly reports on the treatment of this refuse show that more than 25,000 tons of fats have been extracted, and over 160,000 tons of fertiliser obtained, from the household refuse of about 19 million inhabitants.

The flesh of swine fed on this refuse up to 1 October was estimated at 30,000 tons, the refuse being obtained from 12 millions inhabitants.

In accordance with the "Food Control Act" of 10 August 1917, in the United States molasses must be sold according to the trading laws in force in the various localities where produced and, like syrups, cannot be "cornered" (3).

(1) KOLLER, Dr. TH., op. cit.

(2) Cf. *Annual Report of the U. S. Food Administration for the Year* 1918, p. 15. Washington, Gov. Print. Office, 1919.

(3) Cf. The United States Food Administration and the U. S. Fuel Admin. Messages from the President of the U. S., Washington, Gov. Print. Office, 1918.

III. — FERTILISERS.

Agriculturists were well aware, even before the war, that all kinds of vegetable, animal, and even mineral waste, when sufficiently decomposed and subjected to special treatment, can be used as fertiliser.

During the War, therefore, the different Governments did not find it necessary, as in the case of food substances, to take steps to regulate and enforce the collection and utilisation of numerous waste products which were formerly wholly or partially neglected. Nevertheless in certain countries the opportunity, and sometimes the necessity, arose of examining more closely certain questions relating to manuring; and, in consequence, useful and important action was taken.

Privately, as well as officially, through oral and press propaganda, action has been taken to urge farmers to utilise all waste material unfit for human or animal food, so as to lessen, at least partially, the serious consequences attendant on the absolute lack in certain countries, or the great scarcity in others, of the ordinary fertilising matters supplied by the trade.

The greatest need was for phosphatic fertilisers, and then, with the exception of Germany, for potash and nitrogenous fertilisers.

By the employment of more intensive processes for the nitrogen produced by distilling pit-coal and by largely extending the manufacture of synthetic ammonia by the Haber method and that of nitric acid by the Schönherr method, Germany succeeded in producing the nitrogenous substances required in the War and also, to a considerable extent, those needed in agriculture. Her potassic salt mines supplied all the potash needed, but, on the other hand, the importation of phosphates was completely stopped, and she had to confine herself to the constant, but insufficient production from bones.

In the countries of the Entente, on the contrary, while it was possible to keep up, to a limited extent, the supply of mineral phosphates, the quantities of nitrate and potassic salts left over for fertilising purposes by the munition works fill far short of the requirements of agriculture. Hence the synthetic and non-synthetic production of nitrate salts and nitric acid, were carried further, and recourse was had (as will be seen in the Second Part) to vegetable refuse in order to obtain potash ; but if the needs of the armies were satisfied, it was impossible to satisfy, except to a very small extent, those of the soil. It was then that the farmers of their own accord used all kinds of waste matter to maintain, at least partially, soil fertility, as the problem of the food supply became more and more urgent on account of the submarine warfare and the increasing scarcity of labour, which affected every part of the belligerent countries.

The following statistical note (1) shows the quantity of *nitrogen from waste* used in GERMANY on the land cultivated before the war in the 30 chief crops (an area of 81,250,000 acres). The yearly requirement was 3,005,000 tons of nitrogen, of which 1,674,463 tons were forthcoming from different sources, among which waste materials represented the following quantities of nitrogen:

Purin	127,500 tons
Human urine	76,650 »
Solid excrements	100,000 »
Industrial waste products	100,000 »
By products of gas industry	71,300 »
Total	475,450 tons

The difference between this total and the 1,674,463 tons mentioned represents the nitrogen contained in: seeds — atmospheric precipitation — bacteria in legumes — calcium cyanamide — synthetic ammonia — imported nitrate of soda. There was thus a deficit of 1,330,537 tons of nitrogen, which had to be made up for the most part by synthetic ammonia, the production of which was greatly developed.

In AUSTRIA (2), as also in all the other countries, all gas-works were obliged to collect the ammoniacal water and pass it over to the factories engaged in utilising it.

The glue factories had to grind bones to powder, and in order to supply them with the necessary quantity of bones, a thorough system of collection was carried out, especially in the military slaughter-houses. The same took place in the other belligerent conntries.

The transformation of phosphorites into superphosphates entirely ceased, and the small production of basic slag was encouraged as much as possible.

The prices of phosphatic fertilisers of all kinds were regulated by the Order of 31 July, 1915, No. 224; the Order of 11 May, 1916, No. 136, placed under one management the undertakings connected with bones and their derivatives, and the subsequent Orders (of 11 May and 29 June, 1916, Nos. 137 and 206) fixed the prices.

"Hohlendünger" (cave fertiliser = bats' excrement) was also utilised, but the scarcity of phosphates continued to increase to such an extent that in 1918 only 7,090 tons of ground bones and 1190 tons of superphosphates were available. In 1919 the quantity of ground bones fell to 500 tons.

(1) Cf. INTERNATIONAL INSTITUTE OF AGRICULTURE, *International Review of the Science and Practice of Agriculture*, Nov. 1921, No. 1091.

(2) According to H. KALLBRUNNER's Report, already quoted (See p. 38).

In Belgium (1), the Governor General, by a Decree dated 27 March, 1916, fixed the following maximum prices for the different chemical fertilisers, waste products, etc.:

Fertilisers.

	Price per kilo of nitrogen, in francs
Powdered horns	2.10
Ground dry blood	2.60
Powdered hides, wool waste and other similar products:	
a) raw.	0.50
b) dissolved by steam or sulphuric acid	2.10
Crude ammoniac products	3.20
Composite organic fertiliser dissolved by sulphuric acid	2.70

At the end of 1916, the "Coal Control" placed at the disposal of the Agricultural Department 117 tons of ammoniacal water containing 5 % of nitrogen, 30 tons of sulphate of ammonia manufactured by means of bisulphate and peat and 40 tons of residuary matters containing 5 % of nitrogen and lime.

The Department had these various fertilisers used on the spot either by spreading them on the bare ground or by pouring them into purin cisterns.

Use was also made of a fertiliser called "*Poudro*" coming from sifted street sweepings, poor in fertilising principles but of rapid action. The following quantities were bought and distributed:

in 1915	2,400 tons
1916	1,800 »
1918	530 »

Regarding *mill dusts* the Agricultural Section was informed that they were bought for preparing livestock feeds and for mixing with fertilisers. As this dust contained spores and other injurious matters, the Agricultural Department decided to take measures to prevent its being placed on the market.

From an investigation made on the subject during the month of December 1915, by M. Graftiau, at the request of the Agricultural Department, it was found that the quantities collected were from 1,000 to 1,200 kg. per week in each factory. All this dust was sent at the expense of the *Comité National* to a factory at Brussels, which paid 7 francs per 100 kilos for it. In this factory the waste matters were separated as follows:

(1) Cf. *Rapport spécial sur le fonctionnement et les opérations de la Section agricole du Comité national de secours et d'alimentation*. Section agricole, 1914-1919. Brussels, 1920.

1) Wheat small straws, for lining brewers' vats and for feeds treated with molasses.

2) Husk, fine straw refuse, etc., especially for feeds treated with molasses.

3) Small seeds and grain offals, for poultry.

4) Dusts, sold at 4.50 fr, per 100 kg., for preparing fertilisers.

M. GRAFTIAU drew the following conclusions from his investigation :

" *a*) All mill dusts should be sent to central depots and screened, in order that they may not enter in a raw state into livestock feeds.

" *b*) The consumption of straws, husks, small seeds, is one of the causes of the propagation of diseases of wheat. But as means exist for counteracting these, such products may be used in the preparation of feeds when there is scarcity. It would be desirable however to have them sterilised before use.

" *c*) Dusts separated from plant refuse should be exclusively used for manuring meadow-land. "

Following this report, the " Conseil général de la Ligue de défense contre la fraude " (General Council of the League of Protection against Adulteration) recommended the following measures :

" 1) The sending of all dusts from the cleaning of grain to special establishments for screening in order to prevent their introduction in a raw state into livestock feeds.

" 2) The work to be done as job work as in milling and the sales to be direct to the consumer, in order that it may be known for what purpose the screened products are intended.

" 3) Sale of the cleaned (" depoussiérés ") products for the following purposes :

" *a*) Small straws (*Paillettes*) for brewing or as forage.

" *b*) Husks and fine residues for the manufacture of feeds treated with molasses, etc. (Preference should be given to uses in which the sterilisation of the germs is brought about).

" *c*) Small seeds and grain residues for poultry.

" 4) Sale of the dust as fertiliser for meadow land.

" From an analysis of two samples of mill dust made for the " Comité National " at the State Laboratory for Analyses (" Laboratoire d'analyse de l'Etat ") at Tervueren, the following approximate estimate of their value as fertiliser was made :

No. 1)	Nitrogen, 2.64 % at 1.50 fr. per kg.	3.96 fr.
	Phosphoric Acid, 1.11 % at 0.50 fr.	0.55 »
		4.51 fr.
No. 2)	Nitrogen, 1.76 % at 1.50 fr. per kg.	2.64 fr.
	Phosphoric Acid, 0.75 % at 0.50 fr.	0.37 »
		3.01 fr.

With a view to unifying the action of the Provincial Committees in this matter, the Agricultural Department brought these measures before the notice of the National Committee in a letter dated 29 January, 1916.

In June 1916, in consequence of another letter from the Section on the same subject, the National Committee requested the Provincial Committees to sell no more mill dust to manufacturers or middle men, but to place them at the disposal of the farmers.

In October 1916, the Section called the attention of the Provincial Sections to an offer by the firm LAGRANGE of Antwerp to pay 20 francs per 100 kg. delivered at Antwerp for fine and coarse wheat husks and " paillettes " obtained by treating mill dusts. They were to be employed for manufacturing a feed mixed with molasses called " Sucréma ".

" Such, " — to quote the Department — " were the meagre sources of supply in fertiliser at the disposal of our farmers during the War. It is surprising that with the shortage of farm manures, reduced both in quantity and richness through the decrease in livestock and poorer feeding and in the almost total absence of chemical fertilisers, the production of the soil in Belgium could be maintained for a period of 4 years at a respectable level. To effect this, the country had to utilise the accumulated reserves of manure. She encroached on her capital and impoverished her working resources ".

In the UNITED KINGDOM, very active measures were taken to ensure the nitrogen necessary not only for the manufacture of munitions, but also for agriculture. Although the general conditions of the supply of raw material had become more and more serious, even in this country, her colonial and foreign trade was never entirely cut off. Nevertheless, very valuable work was done by the Nitrogen Products Committee, and the publication of all the results of its investigations was very useful (1).

Of the numerous subjects treated in detail in the work refered to above, mention only will be made of the following, which will be considered from the technical point of view in Part II: Nitrogen from schists — Nitrogen from peat — Nitrogen from sewage waters — Nitrated products of agriculture — etc.

The Ministry of Munitions of War issued a Decree dated 7 August 1917, ordering that the production of blast-furnace (" haut-fourneau ") dusts, trading in the same, their treatment and analyses, be submitted to the Controller of Potash Production in the Ministry.

The " Food Production Department " supplied the Agricultural Experiment Station at Rothamsted with the necessary funds for a series of investigations having as their object the discovery of the

(1) MINISTRY OF MUNITIONS OF WAR, *Nitrogen Products Committee, Final Report*. London. H. M. Stationery Office, 1920.

best means of transforming straw into manure without first using it as litter.

In SCOTLAND the Commission of Enquiry on Food Production in one of its Reports suggested among other points the following (1):

1) Carefully keeping human fertiliser for application to the soil.

2) Using as forage all suitable straw and for litter replacing straw by peat.

3) Utilising as much as possible the sewage waters of towns and villages.

For the manufacture of nitrate fertilisers, in FRANCE, M. DESHAYES, Deputy for the Oise, took the initiative in recovering dried blood and other residues. The recovery of these products was only organised in 1916. All slaughter-house offals (bones, horns, blood, etc), were received at a Central Depot at Ablis Paray (Seine & Oise) (2).

To make good the lack of potash, full use was made of the salt pits at Giraud in Camargue, and the salt marshes and lakes of Tunis, also molasses and the water in which wool had been scoured (3).

In the " Recueil de lois, decrets, arrêtés, etc. intéressant le ravitaillement de la France (4) " (vol. VII, 1921, p. 269) we find a " Liste et Quotités des produits alsaciens-lorrains exempts de droits d'entrée en Allemagne par l'Art. 68 du Traité de paix " (List and Quotas of products from Alsace Lorraine exempt from import duty in Germany by Art. 68 of the Peace Treaty), to which is annexed the Decree of 29 December 1920, which establishes the exemption as from 11 January 1921 to 10 January 1922.

Among these products, are given belons those bearing on the present article :

10th Rags and waste of all kinds	6,400 tons
28th Coffee grounds	400 »
31st Forest products, osiers for basket making), sawdust and wood chips	1,250 »
51st Vinegar, lees and yeasts	800 »
53rd Waste products of agriculture, including brans	47,630 »
84th Leather waste.	1,680 »

In the UNITED STATES, from May 1916 to April 1918, human food waste was collected in 96 towns, and one town in particular also

(1) Cf. Report by the Dept. Commission appointed to inquire into the question of maintaining and if possible increasing the present Production of Food in Scotland. Edinburgh, 1915.

(2) Cf. CH. MOUREAU, work quoted, p. 137.

(3) Cf. CH. MOUREAU, op. cit. p. 177.

(4) To facilitate the utilisation by Planters in the French Colonies of residues from colonial industries, the Directors of the *Revue Agricole* of Réunion Island (nº. 10, 1921) conceived the idea of offering the farmers a book dealing with residues. With this object in view,

took steps to extract the fats from them. The total population of these towns was about 26 millions. The waste collected in the two years amounted in all to 4,998,066 tons ; in 12 towns, with a population of 7,684,711, 1,055,118 tons of waste were collected in the two years, from which 21,749 tons of fats were extracted (1).

It has been proved that the extraction of fats from sewage by industrial processes is not advantageous from an economical point of view.

The extraction of potash from seaweed was also carried further (see page 207).

IV. — WASTE AND RESIDUE STATISTICS.

The great economic importance of waste products and residues is clearly shown by the statistical data available in the case of many materials, but unfortunately in the present state of statistical research, and owing to the nature of the materials themselves, the quantity of, and trade in many cases still remain undetermined. It would however be useful to be in a position to ascertain what quantity of waste and residues could be depended upon in case of need if any given category has to be subjected to a process of industrial or agricultural utilisation.

The statistical data of the total production are fundamental, but taken alone are not sufficient to give the farmer a precise notion of the different ways in which waste products and residues may be utilised. The data as to production therefore should be followed by other data on the chief uses, already adopted or to be applied, of waste products and residues. Thus, for instance, as regards *Human foods*, when the average content in nutritive assimilable matters is known, the quantity of digestible materiai in the waste products could be ascertained,as well as the number of calories and the relation in value between such material and the foods in ordinary use. These foods could thus be replaced by the waste products and, on this basis, the unit and total value of the residues could also be ascertained.

As to *Livestock feeds*, when the data for production are available and the average content in nutritive digestible elements is known, the quantity of these elements corresponding to the total production can be determined, and then the quantity of ordinary feeds which may be replaced by waste products and also the total saving effected, basing on

the collection of samples of residues from perfume distilleries, etc., and the sending of the samples for analysis in France, has already been begun.

"When the farmer", says the Review, "has before him a residue from an agricultural industry, he should not look upon it as an inert and rotting mass which, after a certain time, will be transformed into mould, but should consider what can be produced from it, whether it be animal, vegetable or household refuse, if utilised thus increasing the value of his holding. — Consequently it is of the utmost importance that he should contrive to utilise these residues".

(1) KOLLER, Dr. TH., work quoted.

average current prices. Further, taking as a basis the figures which represent the proportions of each of the nutritive elements of which the various fundamental rations are composed, the number of rations corresponding to each species of animal and their corresponding value may be determined, according to the total quantity of elements.

As regards *Fertilisers*, after the total production of waste products and their average content in fertilising elements has been determined, the corresponding quantity of these elements may be determined, and afterwards, the quantities of ordinary fertiliser which may be replaced by the waste products, the total area of the different crops which may be fertilised by them, etc.

The International Institute of Agriculture already makes enquiries to determine statistics of the *International Trade in Concentrated Cattle foods* and the *International Trade in Fertilisers and Chemical Products used in Agriculture.* It would be useful in addition to have an enquiry made with special reference to articles not included in these publications, so as to obtain on as comprehensive a scale as possible statistical data for the production of waste material and residues.

Certain difficulties would undoubtedly arise in such an undertaking, from the nature of the refuse, the more or less rapid wastage and deterioration after production, as well as difficulties in collection and transport, but these need not be considered as prohibitory for all waste products. Those, indeed, for which positive data can neither be collected nor determined, would be set aside, but for many others direct or indirect statistics can be furnished, and the enquiry can do much to lay down the lines of such statistics.

Though this enquiry should relate to a considerable number of products, it can be conducted with comparative ease, because the waste products and residues are often plentiful on the markets and their statistical data well known. In any case, it is not necessary to give statistics for all the materials treated in this book. In the first instance, all available information might be collected for publication, the statistics being amplified in proportion as new data are obtained.

Among the large number of products, there are many for which direct data could be obtained ; but, in the case of others, this will not be possible. The difficulty could then be overcome by indirect research, that is, the figures could be obtained from the percentage of the waste product or residue in the corresponding original product, for which accurate data can be more easily obtained.

The data should relate to uses of residues as well as quantities, and the statistics classified accordingly.

There are however waste products and residues for which, even by such a method, statistics would not be forthcoming, since there are products for which it would be impossible to determine the total waste.

In such cases the statistics of the finished products will serve, if not to give an exact idea as to the world or local production of a certain residue, at least to show the degree of utilisation attained and the quantity of the products obtained.

At present statistics of residues are made by the International Institute of Agriculture only in the following cases: the Milling of cereals, Oil Extraction from Seeds and Oleaginous Fruits, Sugar Refining, Brewing and Distilling, Bones and Bone Fertilisers (Trade), and Organic Nitrogenous Fertilisers (Trade). The last group includes : *a*) residues of horns and hoofs for fertilisers ; *b*) various animal residues ; *c*) cake fertilisers ; *d*) soy cake.

It seems therefore, desirable that this work should be extended to include data on the production, prices and trade of the more important and more easily determined waste products and residues, or products extracted from them (oils, alcohol etc).

The following are some of the subjects for which statistics might be drawn up :

Human Food. — Yeasts ; coffee, tea and cocoa and spice substitutes ; By-products and residues of dairies ; Blood etc.

Livestock Feeds. — Straw, pods and husks other than cereal ; Leaves, twigs and tendrils ; Marsh and fresh water plants ; Seaweeds ; Acorns, beech-mast and other forest-tree fruits ; Horse- chestnuts ; Unspecified seeds ; Fecula residues.

Fertilisers. — Grape residues ; olive husks ; Tomato residues ; Tanning refuse ; Papermaking residues ; Mill dust and sweepings; Potash from various industrial residues ; Residues from gas-works ; Soap-works residues ; Cake fertilisers (specified) ; Slaughterhouse offals ; Fish meal ; Meat meal ; Bones and bone products ; Animal glue and lard residues ; Dairy residues ; Wool, horsehair, silk and hair waste ; Leather waste ; Street sweepings and urban refuse ; Utilisation of sewage waters, etc.

Industries. — Alcohol : from sawdust, from cellulose manufacture, from fruits containing starch, arums, and other liliaceae, etc. ; cream of tartar from wine lees, etc. ; Oils from : maize, grape seeds, tomato seeds, melon and pumpkin seeds, tobacco seeds, fruit kernels, lemon pips, beech mast, silkworm-chrysalides, wool fat, fats from household refuse and sewage water, etc.

An attempt has been made, as far as possible, to give some examples of the way in which statistics relating to waste products and residues could be prepared, while in respect to the materials of which the International Yearbook of Agricultural Statistics gives the total production, statistics have been made in accordance with the principles set forth above.

The reader should understand that the general totals in the statistics given in Part II are not completely available in all cases for the simple reason that waste products can neither be all collected nor used in all parts of the world. It is merely desired to give an estimate in order to show the importance of waste products and the advantage to farmers of utilising them, at least in part, in the best possible way.

PART II

COLLECTION, PRESERVATION, TREATMENT, PROPERTIES AND USES OF WASTE MATERIAL FOR HUMAN FOOD AND FEED FOR LIVE STOCK, AS FERTILISER AND IN CERTAIN INDUSTRIES.

In Part II the chief technical considerations in regard to the various waste materials are set out with special reference to their employment as food or feeding stuff, as fertilisers, or in industrial production.

It should be added that for the sake of brevity mention has been made in each case of the main characteristics only, the method or methods of dealing with, handling or preserving the particular residue, and its principal uses.

In a large measure the substances under discussion have been familiar and in general use for a longer or shorter time as the case may be ; but the aim here has been to describe the uses to which they have been put more especially *during the war and after* and to give a clear account of the technical processes rendered desirable and even essential during these six years by the serious shortage of raw materials and of manufactured products.

Some processes are novel, others, already well known, found fresh applications and were often considerably improved. The reader will probably find some subjects of more interest than others, and will decide to concentrate his attention on these.

If this study succeeds in providing a summary of definite information as to the utilisation of waste material, in special reference to farming and farmers, we shall have the satisfaction of having produced a work of a certain usefulness.

I. — HUMAN FOOD.

1. — Bread.

In countries that do not grow enough wheat for domestic consumption, the problem of the bread supply has always been serious, but during the war it became of crucial importance. The legislative and financial measures adopted at that time by the wheat-importing States are a matter of common knowledge : their aim was to prevent the scarcity of bread jeopardising as it did in ancient times the social fabric itself, the maintenance of which the nations engaged regarded as absolutely vital, and strained every nerve to ensure.

Paramount as the question of the bread supply thus became among the economic problems of certain States, it was natural that research should be undertaken and practical application made of new methods. There was also a revival of former methods under pressure of the ever increasing needs and the growing difficulty in producing home grown wheat and other cereals, and still more in importing it from abroad.

Bread substitutes, investigations and trials of expedients for replacing in any way the shortage of breadstuffs, were chiefly developed in the blockaded Central Empires ; but similar methods were adopted outside their limits, particularly after the submarine warfare occasioned the loss of many large cargoes of cereals bound for Europe, making the wheat shortage increasingly acute and dangerous.

With the exception of considerable quantities of pulse, the materials used as bread-stuffs were chiefly either waste products of various industries, or the produce of the cultivated or uncultivated land.

In this chapter, a brief but comprehensive review will be given of the principal waste materials employed, though their use is for the most part discontinued, now that the usual course of trade is re-established and unhindered. The following statement then is to be considered as of chiefly historical interest.

One of the substances most suitably added to bread, both because it is one of its natural constituents and because it increases its nourishing quality without altering its essential characteristics, is *yeast.*

There are various kinds of yeast, but the most important are those that have the property of causing hydrolysis of starch. When specially prepared for food purposes, yeast dries and is easily made into flour.

In GERMANY several kinds of *Nährhefen* (food yeast) were placed on the market, and the chief consumption of yeast during the war was along these lines. By adding 2.5 % of yeast to flour, a " K-bread " is prepared which is especially rich in albuminoids, and of agreeable taste and smell not like those of yeast itself. In " K-bread " the protein content reached 10.54 % estimated on dry matter, even when 20 % of ground potato flakes had been added to the flour (1).

E. JALOVETZ (2) prepared with 92 % of flour and 8 % of dry *Nährhefe*, a bread rich in protein and with a taste and smell not recalling those of yeast. The objection to the use of this yeast however is that it brings about a very large secretion in the organism of uric acid : in fact, 10 gm. of *Nährhefe* set up as much secretion of uric acid as 100 gm. of meat, so that the *Nährhefe* bread was unsuitable for gouty subjects.

To prepare " N-bread " a paste of rye flour is first made and then dry yeast is mixed with it, kneading it till a soft dough is obtained which is cut into shapes.

This bread contained 42.9 % of water, and 15.4 % of proteins estimated on dry matter.

(1) Cf. ROSSMANN and MAYER, N-Brot, ein Kraftbrot-Nährhefebrot-Eiweissreiches Brot, in *Deutsche Essigindustrie*, vol. XIX, 1915.

(2) Cf. *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, vol. 33, 1917.

The nutritive value of the war bread could be considerably increased by adding certain residues, such as skimmed milk, casein, blood etc. (1). Bread making experiments proved that a spongy and palatable bread was obtained by adding to the flour up to 10 % of sugar and 20 % of dried skimmed milk or casein.

A bread that was said to be light and good was prepared with 50 parts of raw potatoes grated, 50 parts of cooked potatoes, 50 parts of grated carrot, 5 % of sugar and a little salt, kneading the whole with skim milk and yeast, letting it rise for 6 hours at a temperature of 30° C, then mixing in 10 parts of dried skim milk and as much flour with a high extraction (*Kriegsmehl* = war flour) as was needed to make a sufficiently hard paste, i. e. about 70 parts.

As has been said *blood* (serum) was also added to bread with a view to enhancing its nutritive value, and at the same time utilising the oxygen set free by the aerated water added to make the bread spongy (2). The blood is kept in a refrigerator for 24 to 36 hours, then the serum is separated from the coagulum by decanting or filtering and is used alone.

The setting free of the oxygen whitens the bread and checks the action of those micro-organisms, always present in flours, which interfere with satisfactory bread-making.

With a view to increasing the quantity of breadstuff flour, recourse was had to *ground decorticated cotton cake*, generally used for feeding stock.

C. A. Wells (3) predicts a great future for this ground cake as human food. From 1914 onwards this cake was dealt with by a number of cereal mills and a fine meal was ground from it, containing a much less quantity of crude cellulose than that found in the decorticated cake itself.

This meal contains twice as much protein as does meat, but it is a vegetable protein which according to a number of physiologists is not the equivalent of an animal protein.

As this flour is difficult to knead, wheat flour is mixed with it, especially for bread and cake making.

The author quoted above has tried this flour on himself for some length of time without experiencing any ill effects. It appears to be thoroughly digestible: its nutritive value, expressed in calories, is higher than that of meat, while the price is very low.

With the process of breadmaking, advocated by W. Ostwald and A. Riedel (4) the question of substitutes is opened: according to these authors, it is possible, or at least it was possible during the war, to replace within certain limits for the purpose of breadmaking the gluten of cereal flour by starch paste. By using a paste of potato

(1) Cf. H. Kühl, Kriegsbrot, in *Zeitschrift fur öffentliche Chemie*, vol. 21, 1915.

(2) Cf. R. Droske, Kraftgebäcke, in *Chemiker-Zeitung*, vol. 39, 1915.

(3) Cf. *Journal of Industrial and Engineering Chemistry*, vol. 6, 1914.

(4) Cf. W. Ostwald and A. Riedel, Getreidemehlloses Geback, in *Chemiker-Zeitung*, vol. 35, 1915.

starch and chemical yeast (1) they succeeded in obtaining a satisfactory potato flour bread : and bread was also made with mixtures of potato flour and tapioca.

Decidedly good results were obtained from an experiment in making bread with potato flour and compressed yeast, reduced to an acid paste.

During the war the fact was recalled in Germany that the Russian peasants, especially in bad seasons make use of a plant called "Krasnaja trava" (red plant) for making breadstuff flour. This plant according to information given by Nikolaj BUSCH, Keeper of the Petrograd Botanical Garden, appears to be *Amaranthus paniculatus* L. or *Atriplex rosea* (2). A variety of the former with white seeds, called *Landesi*, is grown in North India, under the name of *Ranatampala*, but it seems that this is not the Linnean species, but the *Amaranthus paniculatus* of HOOKER corresponding to the *Amaranthus hypochondriacus* of LINNAEUS, and to the *A. erythrostachys* of THELLUNG.

Shortly after the beginning of the war it was reported from Germany that a process had been invented for making a nourishing flour or meal out of wheat and oat straw. A great deal was said about it at the time, but the question was put aside, and straw remained straw, good at best as a feed but not as a bread stuff (see p. 63).

When the utilisation of waste material as livestock feed is considered, the different processes, especially as employed in Germany, for making straw more appetising and digestible will be described (see p. 92). Here certain attempts to use straw for human food are recorded, attempts of which today even in Germany nothing remains beyond the memory.

Oat straw meal was used to make bread. The percentage composition of the straw and the bread are here given (3).

	Oat straw flour	Bread made from this flour
Water	9.61 %	34.56 %
Albuminoids	2.95	6.07
Fats	2.58	traces
Carbohydrates and cellulose	76.58	57.52
Ash	10.28	1.85
Silica	4.63	—

There is thus no advantage in an admixture of oat-straw flour with cereal flour, as the bread is much inferior.

(1) Cream of tartar + bicarbonate of soda, or tartaric acid + bicarbonate of soda, or carbonate of ammonia.

(2) Cf. *Zeitschrift für Untersuchung der Nahrungs und Genussmittel*, vol. 29, 1915. — An investigation into the question seems to point to its being *Amaranthus paniculatus*. Cf. *Polnaja Enziklopedija Russkago Selskago Krosiajstva*, vol. IX, p. 87. Devrien, St. Petersburg, 1905. — In Greece, the flower-buds of *Atriplex rosea* are eaten as capers.

(3) Cf. RÖHRIG, ARMIN, Haferstrohmehl, in *Bericht der Chemischen Untersuchungsanstalt*, No. 32. Leipzig, 1915. Summarised in *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, vol. 53, 1917.

The author of the foregoing analyses, A. Röhrig (1), says that in Germany flour for flouring bread was sometimes made from wood, straw, or husk ; carbonate of lime, chalk, talc and other mineral substances were also used, owing to the prohibition of the use of cereal flour for the purpose. A decree of 13 June 1917 allowed flour of vegetable ivory to be used (2).

Besides the materials mentioned, *bicarbonate of ammonia* was employed in Germany (3) as a substitute for fats in breadmaking, that is to replace the fat used before the war to smear the loaves in order to prevent sticking to the oven. This process, diccovered by a Minden baker, consisted in making a paste with potato-flour to which was added a little bicarbonate of ammonia solution. This was brushed over the sides and under part of the loaves to prevent adhering.

2. — Wheat Germs (4).

In the manufacture of flour for very white bread according to modern systems of milling wheat, the germs or embryos are removed. These are then separately treated, either for making a special flour of high nutritive value, or for the extraction of lecithin, used in medicine as a tonic.

This germ flour contains : nitrogenous substances 40 to 50 % — fats 9 to 10 % — starch 30 % — cellulose 5 to 10 % — mineral substances 4 to 5 %.

The proportion of lecithin is 20 % including : phytine, nuclein, nucleoalbumin, and phospho-organic salts.

3. — Yeast.

Among the materials composing the food rations in Germany there was a special yeast, known as *Nährhefe* (nutritive yeast) (5).

Opinion varied very much about this yeast : owing to its high cost its use is rather as a condiment than as a food (6).

Following the examination made by Herr Schottelius (7), the nutritive yeast prepared by the Berlin *Anstalt für Gärungs-ge-*

(1) A. Röhrig, Streumehl, in *Beicht der Chemischen Untersuchungsanstalt*, vol. 33, Leipzig, 1913. Summarised in *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, vol. 33, 1917.

(2) Stadthagen H., *Beiträge zur Kriegswirtschaft*. Ersatzlebensmittel in der Kriegswirtschaft, parts 56-58. Berlin, 1919.

(3) W. Murtfeldt, in *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, vol. 31, 1916.

(4) Cf. P. Razous, *Les déchets et sous-produits industriels*. Dunod, Paris, 1921.

(5) Cf. Dr. H. Krüger and Dr. G. Tenius, *Beiträge zur Kriegswirtschaft*, Part 14, Die Massenspeisungen. Berlin, 1917, p. 22.

(6) Cf. A. Röhrig, *Berichte der chemischen Untersuchungen der Chem. Untersuchungsanstalt*. Leipzig, 1915.

(7) *Deutsche medizinische Wochenschrift*, No. 41, 1915 and *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, vol. 36, No. 314. 15 August 1918.

werbe is a powder of a light brown colour, resembling semolina, of neutral, scarcely noticeable, taste and with the smell of burnt sugar. It is not soluble either in hot or in cold water. When examined under the microscope it proves to be formed of oval cells of yeast.

According to the analysis made at the above named Institute it contains: albumin 54 % — fat 3 % — non-nitrogenous extracts 28 % — water 8 % — ash 7 %. As regards nutritive value, 1 kg. is equivalent to 3 kg. of semi-fatted beef. Foods containing *Nährhefe* have no unpleasant taste and no ill effects.

1 kg. of *Nährhefe* gives 4520 calories: in 1915 it cost 2.5 marks.

No investigation of the written accounts makes it quite clear what is exactly the nature of this yeast. The conclusion to be drawn is that it has been intentionally kept a secret, and particulars of its post war manufacture and use for human food are also not to be obtained.

4. — Ground decorticated cotton cake (1).

This residue of the extraction of oil from cotton seed, already mentioned, has been described as a wholesome food, richer in protein than meat, and suitable as a meat substitute in small quantities: one ounce of this cake replaces 2 ounces of meat, while the daily ration of an adult should not exceed 2 to 3 ounces. It may be used for making bread, biscuits etc. like wheat flour, with which it may be mixed in the proportion of one part to four parts of wheat flour.

This ground cake is not acceptable to every one: some like it and some do not. If made from seeds of inferior quality it may be harmful. It contains: protein 43.4 % — fat 13.5 % — non-nitrogenous extracts 22.3 % — cellulose 5.4 % — water 8.5 % — ash 7 %. The average coefficients of digestibility are: protein 88.4 % — fats 93.3 % — N. free extracts 60.6 %.

According to the experiments made by J. RATHER (2) the protein of ground decorticated cotton cake was digested by the human organism in the ratio of 78.6 % as against 96.6 % for meat. The protein of this cake has thus a coefficient of digestibility equal to that of pulse flour, and nine-tenths of that of cereal flour, and eight-tenths of that of meat.

During the war, ground cotton cake was employed to a limited extent for human food, but owing to the fact that it is not quite harmless except in small quantities, it seems unlikely that there will be any continuance of its use at the present time, and this mention of it is enough to put the facts on record.

Its use for live stock feeding is, on the other hand, more important.

(1) Cf. G. S. FRAPS, Cottonseed Meal as Human Food, in *Texas Agricultural Experiment Station, Bulletin* No. 128. Austin, 1910.

(2) Cf. *Journal of the American Chemical Society*, vol. 36, 1914.

5. — Straw meals.

At the beginning of the war, news reached the countries engaged, through the medium of sundry periodicals, that a process had been invented in Germany for the manufacture from straw, hay and other parts of plants, of a meal suitable not only as a feed for live stock but also as human food (1). In spite of the importance of the subject, the statement did not carry conviction, and so great was the incredulity expressed that the matter was dismissed and nothing more was heard of the discovery that FRIEDENTHAL claimed to have made.

It seems desirable here to refer briefly to this process, basing what follows on the experimental results obtained in Germany beginning from the date when the invention was first made public.

W. KERP, F. SCHROEDER and B. PFYL (2) stated in the first instance that FRIEDENTHAL'S experiments had not been systematically carried out, nor verified by the proper scientific tests. They took oat, rye, wheat and barley straw, chopped in varying degrees, from cutting with a chaff-cutter, to grinding in a mill.

The straws selected do not differ greatly as regards soluble substances, their arrangement on an ascending scale being as follows: wheat, rye, barley and oats. These substances are soluble in water, dilute hydrochloric acid, a dilute solution of carbonate of ammonia, or malt extract, to practically the same degree whether the straw has been milled or only chopped, and contrary to the opinion of FRIEDENTHAL the solubility is not affected by the breaking of the cell walls. In any case the quantity of soluble substances is at most ten per cent of the straw and at least one third of them are mineral substances. Larger quantities of substances are dissolved by the action of extract of malt, which makes the temperature rise to 60° C, than by the other solvents.

Since the cereal straws do not contain carbohydrates capable of transformation into sugar under the action of diastase and in particular do not contain starch, these substances cannot possibly be found in straw meals.

Nitrogenous substances soluble in water and substances that may be extracted by ether are present in very small quantities, and consist respectively of albumen and fats only. The proportion of the nitrogenous substances does not exceed one per cent. These components are therefore of no real importance for the nutritive value of the straw and would not in any case pay the cost of milling.

Even ruminants only digest a part of the crude cellulose which represents one third or one half of the straw, and as milling does not

(1) Cf. FRIEDENTHAL, Die Nährwerterschliessung in Heu und Stroh und Pflanzenteilen aller Art. Reichenbachsche Buchhandlung. Leipzig, 1915.

(2) W. KERP F., SCHRÖDER, B. PFYL, Chemische Untersuchungen zur Beurteilung des Strohmehls als Futter- und Nahrungsmittel, in *Arbeiten aus dem Kaiserlichen Gesundheitsamte*, 1915, vol. 50, pp. 232-262. Summarised in *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, April 1916.

modify the physical and chemical properties of the crude cellulose, it cannot increase its digestibility.

The proportion of non-nitrogenous extracts from these straws varies between 30 and 40 %, of which half are insoluble or undigested pentosans: there are also absent all the carbohydrates that could be transformed into sugar by the malt extracts. The remainder consists of: organic acids and their salts — colouring matters — bitter substances — substances not determined — all of which may be considered as having a negligible food value in no way comparable to that of sugar or starch. By use of the solvents already mentioned the following quantities of the different components have been extracted: nitrogenous substances one % — sugar one % — organic acids and their salts one % — mineral acids 3.5 % — substances not fully determined (colouring matters, bitters, tannins) 3.5 %. It is clear from this that even the non-nitrogenous extracts of the straw are valueless as food for non-ruminants and man, so that straw, even when reduced to a meal, is useless as human food.

Experiments with pigs made by ZUNTZ have shown that straw meal is only so much undigested bulk for them. For human feeding it must be absolutely ruled out (1).

6. — Wild plants used for human food.

Man has always used a number of wild plants for food, gathering them when the part or parts utilised for food are at the most suitable stage for the purpose.

Among the rural population of certain regions wild plants form or might form an important source of food and even in some centres of population, as for example in Italy from Rome southwards, there is a large consumption of certain kinds of wild plants as vegetables at all times of the year. This is unfortunately not the case in the majority of the centres of population in the different countries.

During the war the more or less pressing need for food stuffs naturally stimulated the search for wild vegetables so that in addition to the kinds usually eaten plants which in normal times were completely ignored were used as food.

A detailed recital of what has happened in Russia during the recent famine would be out of place here: it is enough to mention that wild plants and even weeds have formed the only means of subsistence for thousands of peasants and other country dwellers.

It is thus worth while to reproduce below some lists of wild plants recommended as food during the war, many of which before that time were not so used or only to a small extent.

It should be noted that the species mentioned represent only a very small number of all those of which some part is edible. For

(1) The flour of various straws was sold in Germany under different names: Futtermehl aus Getreideabfällen, Pflanzenfuttermehl, Futtermehl für Jungvieh und Schweine, Erbsenstrohmehl, Weizenmehlkleie, etc.

full information on the subject, the authoritative work by STURTEVANT, edited by U. P. Hedrick, may be consulted: *Sturtevant's Notes on Edible Plants.* Albany, J. B. Lyon Co., 1919, 1 Vol., quarto, p. 686.

In the preface to this book, dated June 1 1919, W. H. JORDAN, Director of the Board of Control of the New York Agricultural Experiment Station says: " It is especially appropriate that such a volume should be issued at this time. Food problems are becoming more and more acute as the demand for food increasingly overshadows the supply. Primitive peoples depended upon food resources that are now neglected. Other sources of possible human nutrition have doubtless remained untouched . . . "

For tropical plants, the reader should consult the work of A. CHEVALIER : *Les Végétaux utiles de l'Afrique tropicale française.* Paris, Challamel.

The following list, relating specially to Germany, has been taken from the work of L. DIELS, entitled *Ersatzstoffe aus dem Pflanzenreiche,* Stuttgart, Erwin Nägeli, 1918. As a rule, with certain exceptions, the Latin names are given only of wild plants or plants but little cultivated, omitting those usually cultivated for human food or feed for live stock or for providing raw materials. Certain wild plants are also omitted which though more or less utilisable were of little importance even during the war.

1. — *PLANTS OF WHICH THE LEAVES, STEMS, FLOWERS, FRUITS, ROOTS, TUBERS ETC., CAN BE USED AS VEGETABLES, EITHER RAW OR COOKED.*

Barbarea vulgaris — *Nasturtium officinale* — *Cardamine amara, C. pratensis* — *Geum urbanum* — *Veronica Beccabunga* — *Valerianella* sp. — *Bellis perennis* — *Sanguisorba officinalis, S. minor* — *Ulmaria pentapetala* — *Epilobium* sp. — *Primula* sp. — *Taraxacum officinale* — *Achillea Ptarmica* — *Iris Pseudoacorus* — *Portulaca oleracea, P. sativa* — *Salicornia herbacea* — *Agrostemma Githago* — *Ranunculus ficaria* (tubers) — *Berberis vulgaris* — *Sinapis alba* — *Brassica nigra* (*Sinapis nigra*) — *Cochlearia officinalis* — *Sempervivum tectorum, S. soboliferum* — *Sedum reflexum, S. mite, S. album, S. maximum* (tubers) — *Saxifraga tridactylites* — *Galega officinalis* — *Oxalis Acetosella* — *Eryngium* sp. (roots) — *Glaux maritima* — *Samolus Valerandi* — *Brunella vulgaris* — *Glechoma hederacea* — *Borrago officinalis* — *Plantago Coronopus* — *Phyteuma spicatum, P. orbiculare* — *Carduus nutans* — *Cirsium oleraceum, C. arvense, C. bulbosum* — *Urtica dioica, U. urens* — *Humulus Lupulus* — *Chenopodium Bonus-Henricus*, etc. — *Atriplex* sp. — *Beta vulgaris* — *Rumex Acetosa, R. crispus* — *Stellaria media* — *Cerastium caespitosum* — *Holosteum umbellatum* — *Papaver Rhoeas*, etc. — *Brassica Napus, Brassica Rapa esculenta*, etc. — *Sinapis arvensis* — *Nasturtium* sp. — *Erysimum cheiranthoides* — *Sisymbrium officinale*, etc. — *Capsella Bursa-pastoris* — *Lepidium ruderale* — *Medicago sativa* — *Trifolium* sp. — *Malva* sp. — *Aegopodium Podagraria* — *Symphytum of-*

ficinale — *Anchusa officinalis* — *Plantago major*, etc. — *Tussilago Farfara* — *Petasites officinalis* — *Galinsoga parviflora* — *Onopordon Acanthium* — *Lappa* sp. — *Silybum Marianum* — *Pteridium aquilinum* — *Triglochin maritima* — *Poligonatum multiflorum*, etc. — *Polygonum Bistorta* — *Amaranthus* sp. — *Ranunculus repens* — *Crambe maritima* — *Cakile maritima* — *Ononis spinosa*, *O. repens* — *Lythrum Salicaria* — *Daucus Carota* — *Anthriscus Cerefolium*, *A. sylvestris* — *Heracleum Sphondylium* — *Angelica sylvestris* — *Lamium purpureum*, etc. — *Betonica officinalis* — *Pulmonaria officinalis* — *Campanula* sp. — *Helianthus annuus* — *Achillea Millefolium* — *Chrysanthemum Leucanthemum* — *Hypochoeris maculata* — *Sonchus arvensis*, *S. oleraceus* — *Sagittaria sagittifolia* — *Butomus umbellatum* — *Scirpus maritimus* — *Orchis* sp. — *Lathyrus tuberosus*, *L. montanus* — *Oenothera biennis* — *Carum Bulbocastanum*, *C. carvi* — *Chaerophyllum bulbosum* — *Pastinaca sativa* — *Stachys palustris* — *Campanula Rapunculus*, etc. — *Helianthus tuberosus*, *H. macrophyllus*, etc. — *Tragopogon pratensis*, *T. orientalis*.

2. — *PLANTS CONTAINING FECULA OR STARCH (ROOTS, TUBERS, FRUITS, SEEDS, ETC).*

Typha sp. — *Nymphaea alba* — *Nuphar luteum* — *Arum maculatum* — *Calla palustris* — *Alisma Plantago* — *Quercus* sp. — *Aesculus Hippocastanum* — *Chenopodium* sp. — *Glyceria fluitans* — *Panicum sanguinale*, *P. lineare* — *Trapa natans* — *Ulmus campestris* — *Betula* sp. — *Alnus* sp. — *Pinus* sp. — *Picea* sp. — *Polygonum nodosum*, *P. lapathifolium*, *P. Convolvulus* — *Bromus* sp. — *Hordeum murinum* — *Festuca* sp.

3. — *LEGUMINOUS PLANTS.*

Pisum sativum, *P. arvense* — *Vicia hirsuta*, *V. tetrasperma*, *V. Cracca*, *V. villosa*, *V. ervilia*, etc. — *Lathyrus sativus*, *L. sylvestris*, *L. pratensis*, etc. — *Phaseolus* sp. — *Lupinus* sp. — *Ornithopus sativus* — *Robinia Pseudacacia*.

4. — *SUGAR YIELDING PLANTS.*

Glycyrrhiza glabra (roots) — *Betula* sp. (juice) — *Acer platanoides* (juice), *A. Pseudoplatanus* (juice).

5. — *FRUITBEARING TREES AND BUSHES.*

Mespilus germanica — *Crataegus Oxyacantha*, *C. monogyna*, etc. — *Pyrus* sp. — *Sorbus Aucuparia*, *S. domestica*, *S. torminalis* — *Cydonia japonica* — *Amelanchier vulgaris*, etc. — *Rosa* sp. — *Prunus avium*, *P. insititia*, *P. spinosa*, *P. Padus*, etc. — *Berberis vulgaris* — *Mahonia aquifolium* — *Vitis* sp. — *Cornus Mas* — *Sambucus nigra*, *S. racemosa* — *Vaccinium* sp. — *Arctostaphylos Uva-ursi* — *Hyppophäe rhamnoides* — *Physalis Alkekengi*.

It seems desirable to add to the preceding list, the names of certain colonial wild plants, which can be used for the same purposes as those above-mentioned. Here too, only the wild plants are given, and not the species usually cultivated, unless they also grow wild (1):

1. — *PLANTS CONTAINING FECULA OR STARCH.*

Sporobolus affinis A. Rich., *S. indicus* var. *capensis* Wild., *S. panicoides* A. Rich — *Tacca pinnatifida* Forst. — *Boscia salicifolia* Oliv. — *Cissus edenocaulis* Steud. — *Ceropegia convolvuloides* A. Rich. — *Cyanotis hirsuta* A. Rich — *Cyphia glandulosa* Hochst. — Tree-ferns (2), etc.

2. — *LEGUMINOUS PLANTS.*

Lablab vulgaris Savi — *Phaseolus Mungo* L. — *Cajanus Cajan* Millsp. — *Entada sudanica* Schw., *E. abyssinica* Hoch. — *Cordeauxia edulis* Hemsl.

3. — *SUGAR YIELDING PLANTS.*

Sorghum Ankolib Korn. — *Phœnix dactylifera* L., *Ph. sylvestris* Roxb., *Ph. rechicata* Jacq., *Ph. abyssinica* Drude.

4. — *FRUITBEARING TREES AND BUSHES.*

Ziziphus Jujuba Lam., *Z. Spina Christi* L., *Z. mucronata* W. — *Sclerocarya birrea* Hoch. — *Hibiscus esculentus* L. — *Doryalis verrucosa* Warb. — *Syzygium ovariense* Benth. — *Diospyros mespiliformis* Hoch. — *Mimusops Kummel* Hoch, *M. Schimperi* Hoch. — *Strychnos Unguacha* A. Rich. — *Acocanthera abyssinica* Hoch. — *Carissa edulis* Vahl. — *Cordia Gharaf* Ehrenb., *C. abyssinica* R. Br., etc. — *Commiphora Boiviniana* Engl., *C. Paolii* Chiov. — *Flueggea obovata* L. — *Antidesma venosum* Tul. — *Sorindeia somalensis* Chiov. — *Landolphia florida* Benth., *L. Petersiana* Kl. — *Aframonum Korarina* K. Schum.

We reproduce the following list of wild plants, compiled by Prof. TROTTER in a publication issued during the war (3).

PLANTS USED AS HUMAN FOOD.

a) Leaves, buds, etc.: *Pinus halepensis* — *Chamaerops humilis* — *Asphodelus microcarpus*, *A. tenuifolius* — *Iris juncea* — *Cynomorium*

(1) Cf.: 1) E. CHIOVENDA, Materie prime di vegetali spontanei o coltivati nelle nostre Colonie di Eritrea e Somalia. *Istituto Coloniale Italiano*, Rome 1921. — 2) YVES HENRY, Plantes à huile. A. Colin, Paris, p. 201. — 3) H. JUMELLE, Les huiles végétales. J. B. Baillière et fils. Paris, 1921. — (4) IDEM, Plantes industrielles, J. B. Baillière et fils. Paris, 1916.

(2) At Honolulu (Hawaii) a new industry has lately come into existence for extracting fecula of good quality from the medulla of the trunk of tree-ferns (Cf. *Bull. Econom. de l'Indo-Chine*, No. 154, new series. Hanoi-Haiphong, 1922, p. 365.)

(3) Cf. TROTTER, A., *Flora economica della Libia*. Colonial hand-books published by the Ministry of the Colonies. Rome, Tip. dell'Unione editrice, 1915, pp. 319-330.

coccineum — *Emex spinosa* — *Rumex tingitanus, R. vesicarius* — *Atriplex Halimus* — *Portulaca oleracea* — *Brassica Napus, B. Tournefortii* — *Diplotaxis Duvieyrierana* — *Eruca sativa* — *Nasturtium officinale* — *Oxalis cernua* — *Hibiscus cannabinus* — *Statice Thonini* — *Caralluma europaea* — *Phelypaea atropurpurea, P. condensata, P. lutea, P. violacea* — *Salvia Verbenaca* — *Hedypnoides polymorpha* — *Hyseris radiata* — *Koelpinia linearis* — *Scorzonera alexandrina* — *Tragopogon porrifolius.*

b) Flowers or inflorescence: *Allium roseum* — *Muscari comosum* — *Capparis rupestris* — *Carduncellus acaulis* — *Cynara Scolymus, C. Sibthorpiana* — *Onopordon* var. sp. — *Rhaponticum acaule.*

c) Underground parts: *Cyperus esculentus* — *Chamaerops humilis* — *Allium Ampeloprasum* — *Muscari comosum* — *Tulipa australis* — *Alhagi maurorum* — *Bunium mauritanicum* — *Ferula* var. sp. — *Erodium guttatum, E. hirtum* — *Pancratium maritimum.*

d) Fruits or seeds: *Ephedra alata* — *Aristida pungens* — *Dactyloctenium aegyptiacum* — *Panicum miliaceum, P. turgidum* — *Pennisetum dichotomum* — *Hyphaene thebaica* — *Quercus Ilex* — *Mesembryanthemum Forskalii* — *Ficus Telonkat, F. eucalyptoides* — *Capparis Sodada* — *Acacia tortilis* — *Astragalus baeticus, A. lanigerus* — *Vigna sesquipedalis* — *Rhus Oxyacantha* — *Nitraria tridentata* — *Balanites aegyptiaca* — *Arbutus Unedo* — *Salvadora persica* — *Salvia spinosa* — *Citrullus Colocynthis.*

e) Condiments and flavourings: *Erythrostictus punctatus* — *Laurus nobilis* — *Sinapis alba* — *Ammodaucus Leucothricus* — *Crithmum maritimum* — *Petroselinum ammoides* — *Pituranthus tortuosus* — *Balanites aegyptiaca* — *Phlomis floccosa* — *Rosmarinus officinalis* — *Thymus capitatus, T. hirtus* — *Ononis falcata* — *Retama Raetam* — *Trifolium tomentosum* — *Trigonella anguina, T. laciniata* — *Vicia Pseudocracca, V. sativa, V. monanthos* — *Ferula* var. sp. — *Pituranthos tortuosus*, etc. — *Ziziphus Lotus* — *Erodium arborescens* — *Fagonia arabica, F. sinaica* — *Nitraria tridentata* — *Zygophyllum album* — *Haplophyllum vermiculare* — *Malva silvestris* — *Limonastrum Guyonianum* — *Statice Bonduelli, S. globulariaefolia, S. pruinosa, S. Thonini, S. tubifera* — *Periploca levigata* — *Salvadora persica* — *Convolvulus supinus* — *Hyoscyamus Falezlez* — *Phelypaea* (?) *violacea* — *Lavandula coronopifolia, L. multifida* — *Marrutium deserti* — *Globularia Alipum, G. arabica* — *Plantago albicans, P. ovata* — *Anthemis glareosa* — *Anvillea radiata* — *Artemisia variabilis* — *Atractylis serratuloides* — *Calendula officinalis* — *Carduncellus acaulis* — *Centaurea contracta, C. dimorpha* — *Chrysanthemum coronarium* — *Cladanthus arabicus* — *Rhanterium suaveolens* — *Zollikoferia arabica.*

OLEAGINOUS PLANTS.

Juniperus macrocarpa — *Pistacia Lentiscus.*

ALCOHOL YIELDING PLANTS.

Asphodelus microcarpus — *Arbutus Unedo.*

This section should not be concluded without reference to a work of particular interest and value at the present time which was submitted by Prof. O. MATTIROLO, in April 1918, to the *R. Accademia di Agricoltura* of Turin, under the title of Phytoalimurgia Pedemontana (1).

The author describes a considerable number of the wild plants of Piedmont which are fit for human food, but as the greater number of them are also widely diffused in other countries, the subject matter of the book should be of value beyond the limits of Piedmont, and it is for this reason that attention is called to it here.

It should be noted that Prof. MATTIROLO published this book before the war was over (1918) and while there was pressing need for food-stuffs to enable the struggle to be continued at all costs.

MATTIROLO quotes VILLARS, who in 1794 stated in his *Catalogues des substances végétales qui peuvent servir à la nourriture de l'homme*, etc., that in the departments of l'Isère, la Drome and the Hautes-Alpes use was made of only a hundred kinds of food plants, while the ancients made use of not less than 500. " If VILLARS could come to life again " says Prof. MATTIROLO, " he would be horrified to see to what this hundred has shrunk, for in our time there are not more than thirty wild plants that are used for food ".

Further on, our author says : " How extraordinary it is that our rural and particularly our urban population have such a prejudice against using wild plants for food . . .

" I admit that I am not recommending choice foods (we do not have any such now) but I know that the carbohydrates, the nitrogenous substances, and the fats which wild plants contain are identical with those contained in cultivated plants . . .

" If we are not yet reduced to feed only on weeds, at least it is reasonable to look about us and take note of the supplies of food that Nature herself offers. "

In dealing with the different kinds of plants the author has arranged his material solely from the point of view of food, whilst at the same time keeping more or less to the classification proposed 1800 years ago by GALEN in his *Treatise on Foods*. He thus obtained the following 12 chapters :

I. Stems transformed for storage of plant-food : (A) Rhizomes — (B) Tubers, Bulbous-tubers and Tuberous-rhizomes — (C) Bulbs.
II. Roots transformed for storage of plant-food.
III. Young shoots, soft, juicy and edible.
IV. Plants, the leaves and spring-growths of which are used in salads.

(1) MATTIROLO, O., Phytoalimurgia Pedemontana, ossia Censimento delle specie vegetali alimentari della Flora spontanea del Piemonte, in *Annali della R. Accademia di Agricoltura di Torino*, vol. 61, 1918, p. 107. V. Bona, Turin — A full bibliography of the subject is attached to this work. The numerous illustrations are taken from *Compendio della Flora Italiana* of FIORI and PAOLETTI. (Cf. Prof. A. FIORI. Iconographia Florae Italicae, or *Flora Italiana illustrata*, 2nd ed. enlarged. Sancasciano Val di Pesa, 1921).

V. Plants, the spring-growths of which are especially used for soups.
VI. Plants used in omelets and cakes.
VII. Flowers used as food.
VIII. Fruits and seeds used as food.
IX. Oil-yielding plants.
X. Plants or parts of plants used as substitutes for tea and coffee.
XI. Fungi — Algae (1) — Lichens.
XII. Bibliography of Food-Production.

In order to complete the preceeding list it has been thought advisable to mention here the species classified by Prof. MATTIROLO which are arranged in the order set out immediately above. For the sake of brevity the common name of each species is omitted, only the Latin name being given.

RHIZOMES.

Aspidium Filix-mas Sw. — *Arum maculatum* L., *A. italicum* Mill. — *Iris germanica* L. — *Polygonatum multiflorum* All. — *Tamus communis* L. — *Alisma Plantago* L. — *Sagittaria sagittifolia* L. — *Typha latifolia* L. — *Butomus umbellatus* L. — *Cynodon Dactylon* Pus. — *Nymphaea alba* L. — *Nuphar luteum* Sm. — *Orobus tuberosus* L. — *Polygonum Bistorta* L. — *Calystegia sepium* L. — *Menyanthes trifoliata* L.

TUBERS, BULBOUS-TUBERS AND TUBEROUS RHIZOMES.

Gladiolus communis L. — *Crocus vernus* L. — *Colchicum autumnale* L. — *Stachys palustris* L. — *Cyclamen europaeum* L.

BULBS.

Tulipa sylvestris L., *T. clusiana* D. C., *T. praecox* Ten. — *Lilium Martagon* L. — *Muscari comosum* Mill., *M. racemosum* Mill., *M. botryoides* Mill. — *Ornithogalum narbonense* L., *O. pyrenaicum* L., *O. umbellatum* L., *O. termifolium* Guss. — *Allium vineale* L., — *Leocojum vernum* L. — *Erythronium Dens-canis* L.

ROOTS.

Asphodelus albus Mill. (*A. ramosus* L.) — *Orchis Morio* L., *O. maculata* L., *O. latifolia* L., *O. variegata* All., *O. fusca* Jacq., *O. sambucina* L., *O. globosa* L., *O. militaris* L., *O. mascula* L. — *Corydalis cava* L. — *Ficaria ranunculoides* L. — *Spiraea Filipendula* L. — *Sium sisarum* L. — *Bunium Bulbocastanum* L. — *Symphytum tuberosum* L. — *Campanula Rapunculus* L. — *Bryonia dioica* L. — *Onopordon Acanthium* L. — *Scorzonera hispanica* L.

(1) For the gelatine of the Algae (agar-agar), cf. I. A. FIELD. *Chem. Age*, vol. 29. No. 12. N. Y., 1921.

YOUNG STEMS.

Humulus Lupulus L. — *Asparagus officinalis* L., *A. tenuifolius* L., *A. acutifolius* L. — *Ornithogalum pyrenaicum* L., *O. narbonense* L. — *Ruscus aculeatus* L. — *Tamus communis* L. — *Polygonatum multiflorum* — *Chenopodium Bonus-Henricus* L. — *Berberis vulgaris* L.

SALADS.

Erythronium Dens-canis L. — *Paretaria officinalis* L. — *Urtica dioica* L., *U. urens* L. — *Rumex alpinus* L. — *Polygonum Bistorta* L. — *Lamium album* L. — *Ajuga reptans* L. — *Veronica Beccabunga* L. — *Campanula Rapunculus* L. — *Phyteuma orbiculare* L., *P. Michelii* All., — *P. spicatum* L. — *Lapsana communis* L. — *Leontodon hastilis* L. — *Pieris hieracioides* L. — *Crepis faetida* L. — *Tragopogon pratensis* L. — *Hypochaeris radicata* L. — *Taraxacum officinale* D. C. — *Lactuca scariola* L. — *Sonchus arvensis* L., *S. oleraceus* L., *S. asper* Vill. — *Cichorium Intybus* L. — *Bellis perennis* L. — *Portulaca oleracea* L. — *Valerianella olitoria* L. — *Poterium Sanguisorba* L. — *Ononis spinosa* L. — *Silene inflata* L. — *Barbarea praecox* R. Br. — *Diplotaxis tenuifolia* D. C. — *Eruca sativa* L. — *Nasturtium officinale* D. C. — *Bunias Erucago* L. — *Calepina Corvini* Desv. — *Capsella Bursapastoris* L. — *Thlaspi perfoliatum* L. — *Ficaria ranunculoides* — *Papaver Rhoeas* L. (1).

PLANTS USED FOR SOUPS.

The composition of different cooked dishes made from 64 species of plants is shown in tabular form (op. cit., pp. 209-213).

PLANTS USED FOR OMELETS AND CAKES.

Melissa officinalis L. — *Pyrethrum Balsamita* L. — *Artemisia Absinthium* L., *A. dracunculus* L. — *Apium Petroselinum* L. — *Rosmarinus officinalis* L. — *Salvia pratensis* L. — *S. sclarea* L., *S. officinalis* L., *S. glutinosa* L. — *Ocymum Basilicum* L. — *Thymus Serpillum* L. — *Sonchus oleraceus* L., *S. asper* L. — *Plantago lanceolata* L., *P. media* L. — *Urtica dioica* L. — *Hypochaeris radiata* L. — *Papaver Rhoeas* L. — *Lamium purpureum* L., *L. maculatum* L. — *Stellaria media* Vill. — *Medicago sativa* L. — *Parietaria officinalis* L. — *Lapsana communis* L. — *Sinapis arvensis* L. — *Raphanus Raphanistrum* L. — *Rumex Acetosa* — *Bunias Erucago* L. — *Silene inflata* L.

FLOWERS USED AS FOOD.

Cucurbita sp. — *Impatiens* sp. — *Bellis perennis* — *Tropaeolum majus* L. — Violets — Roses — Jasmine — *Robinia Pseudo-acacia*

(1) Various species of *Salicornia* have long been used, and were used considerably during the war either preserved in vinegar or cooked in various ways. As regards the use of these sea-shore or salt land plants compare *Revue d'hist. nat. appl.*, Vol. III, No. 7. Paris, 1922. pp. 199 and 206.

L. — *Cytisus Laburnum* L., *C. alpinus* L. — *Nimphea* sp. — *Nuphar* sp. — *Magnolia Yulan.*

FRUITS AND SEEDS USED AS FOOD (RAW, COOKED, GROUND INTO FLOUR, ETC.).

Fagus sylvatica L. — *Corylus Avellana* L. — *Quercus pedunculata* Ehrh., *Q. sessiliflora* Sm. — *Trapa natans* L. — *Prunus Mahaleb* L., *P. spinosa* L., *P. Padus* L., *P. Brigantiaca* Vill. — *Cornus Mas* L. — *Pyrus torminalis* Ehrh., *P. Aucuparia* Gaert. — *Cerasus Avium* L. — — *Pyrus Aria* Ehrh. — *Berberis vulgaris* L. — *Rubus fruticosus* L., *R. caesius* L. — *Physalis Alkekengi* — *Vaccinium vitis-idaea*, *V. myrtillus*, *V. uliginosum* — Raspberry and strawberry — *Ribes Grossularia* L., *R. alpinum* L., *R. petraeum* Wulf, *R. nigrum* L., *R. rubrum* L. — *Sambucus nigra* L. — *Celtis australis* L. — *Pinus Cembra* L. — *Aesculus Hippocastanum* L.

7. — Substitutes for coffee, tea, cocoa, spices, etc.

At the beginning of the war after the blockade of the Central Empires had been established, there speedily followed an increasing scarcity of coffee, tea etc., and every means was taken to meet first the shortage and then the complete absence of these commodities.

For this reason especially in Germany a large number of substitutes came to be recommended and actually sold, some of which had been in use even before the war: later on as the need became more pressing and the investigation of resources was extended long lists were drawn up of wild plants and of parts of them (seeds, tubers, bulbs, etc.) stated to be more or less suitable for making a beverage that might be called tea or coffee. Very few of these plants thus put to a new use are fit to be retained for the purpose, but out of the large number probably some may be considered as taking their place among the substitutes for stimulants with the advantage that they do not contain more or less harmful alkaloids.

It seems worth while therefore to give some general account of the subject and to indicate broadly the kinds of plants used and recommended as coffee and tea substitutes. From the importance attaching to substitutes in the Central Empires, Germany of course took the lead in this matter. In the Allied States, in so far as overseas trade was possible apart from the submarine activity, real tea and coffee were always obtainable, and the problem of substitutes was of much less importance than in the Central Empires, especially in the last years of the war (1).

A list is subjoined of substances that had been employed in the preparation of coffee substitutes more or less freely before the war the use of which was greatly increased during the war.

(1) Cf. : 1) BÜRSTENER, FR., *Beiträge zur Kriegswirtschaft*, Die Kaffee-Ersatzmittel vor und während der Kriegszeit. Berlin, 1918. — 2) ROSELIUS F., etc., *Beiträge zur Kriegswirtschaft*, Kaffee, Tee, Kakao, in der Kriegswirtschaft. Berlin, 1918.

Pulse takes the first place, but in 1918 the use of it was forbidden for any purpose other than direct feeding. Then follow tubers and roots : tubers of artichoke (Jerusalem) and dahlias, roots of dandelion, salsify, elecampane (*Inula Helenium*), burdock (*Lappa* spp.), feverfew, star-thistle (*Carlina vulgaris*), galingale (*Cyperus esculentus*), the wood pea (*Orobus tuberosus*), common reed (*Phragmites communis*), arrowhead, reed mace (*Typha angustifolia* and *T. latifolia*), the male shield fern and the bracken fern, quaking grass (*Briza* sp.), parsnip, sugar beet, yellow water lily, etc.

Next come the vetch seeds (Kaffeewicke), carob seed, chestnuts, horse chestnuts, asparagus berries (1) (also asparagus refuse), beech mast, seeds of pumpkin, melon and watermelon, sunflower, hemp, lime tree, robinia, beet root, buckwheat, goosefoot, of *Ruscus aculeatus* (butcher's broom), *Galium* spp., camelina, broom, evening primrose (*Oenothera biennis*), plaintain, serradella, water calthrop (*Trapa natans*), ranunculi, etc.

Then the fruit of the medlar (or loquat), of the service tree juniper, sloe, elder tree, dogwood (2), berberis, wild rose, cranberry (*Oxycoccus palustris*), mulberry, holly, etc.

Finally the dried yeasts of wine and beer.

A coffee substitute was also made in Germany from the dregs of beer casks by the following process : filtering in a filter press for separation of the brewers' grains, then drying in a roasting apparatus at 100° C. By the method patented by BERCHTOLD of Berlin, the drying is done at 180° C to 230° C (3).

During the war investigations were made as to coffee substitutes in countries far removed, the results being afterwalds made known in European countries. Among others may be noted the observations made in the Laboratory of Agricultural Chemistry at Poona (British India) (4) on the roasted grains of *Cassia Tora*, a bushy weed, the seeds of which are sold under the name of artificial coffee and coffee substitute. When powdered they look like coffee, but the smell and taste of the infusion is different, although pleasant. These seeds contain a glucoside, hemodin.

In the districts of Waterberg, etc. (Transvaal) the natives employ as chicory the dried root of *Capparis albitrunca*. A London firm informed the Imperial Institute that it was an excellent substitute for chicory in coffee (5).

(1) M. G. SCHROETER, in *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, vol. 32, part. 11, 1916, has proved that asparagus berries when roasted have a flavour much resembling that of real coffee powder. The infusion is pleasant, a little sweet, with no bitter taste. These roasted berries contain : water 6.82 % — nitrogenous matter 17.5 % — ether extract 8.63 % — water extract 32.69 % — invert sugar (reducing) 8.80 % — mineral substances 4.69 %.

(2) The dogwood (*Cornus Mas* L.) has been the subject of a special study by C. GRIEBEL (*Zeitschrift für Untersuchung der Nahrungs- and Genussmittel*, vol. 34, part 5, 1917) : he says that the fleshy part of the berries can be used in making preserves and that the seeds yield a coffee substitute.

(3) KOLLER, Dr. TH., op. cit., p. 50.

(4) TAMHANE, V. A., in *The Poona Agricultural College Magazine*, vol. IX, No. 1, 1917.

(5) *Bulletin of the Imperial Institute*, vol. XV, No. 1. London, 1917.

There have been also numerous substitutes for *tea*, as appears from the lists of plant species reproduced later on. *German tea* was prepared in 1917 by the consumers themselves and consisted of mixtures of leaves of myrtle, raspberry, strawberry plant, bramble, flowers of the lime, of heather, woodruff, and camomile.

In South Germany special use was made of the fruits of the wild rose (hips) and also of apple peelings and dried apples.

A special brand of tea called "Odenwalder Gebirgs-Krauter-Tee, Marke-Graco" consisted of a chopped mixture of the flowers of lavender and elder, liquorice root, leaves of coltsfoot, of the strawberry plant, of bramble, birch and water mint (1).

The species of plants used, or stated to be suitable for use, as substitutes for coffee, cocoa, tea, tobacco, and spices, are grouped in the following lists.

SUBSTITUTES FOR PLANTS YIELDING STIMULANTS AND ALKALOIDS; AND SUBSTITUTES FOR SPICES (2).

SUBSTITUTES FOR COFFEE: *Arachis hypogeaa* (seeds) — *Cassia occidentalis* (seeds) — *Astragalus baeticus* (seeds) — *Beta vulgaris* (roots) — *Brassica Rapa* (roots), *B. Napus*, (roots) — *Daucus Carota* (roots) — *Solanum tuberosum* (tubers) — *Scorzonera hispanica* (roots) — *Cichorium Intybus* (root) — *Taraxacum officinale* (root) — *Triticum repens* (root) — *Phragmites communis* (roots) — *Hordeum sativum* (seeds) — *Secale cereale* (seeds) — *Zea Mays* (seeds) — *Asparagus officinalis* (seeds) — *Iris Pseudoacorus* (seeds) — *Quercus pedunculata* and *Q. sessiliflora* (seeds) — *Fagus sylvatica* (seeds) — *Berberis vulgaris* (fruit) — *Rosa canina* (fruit) — *Prunus avium* and *P. amygdalus* (seeds) — *Crataegus Oxycantha* (fruit) — *Sorbus Aria* and *Sorbus Aucuparia* (fruit) — *Robinia Pseudacacia* (seeds) — *Sarothamnus scoparius* (seeds) — *Lupinus luteus* and *L. angustifolium* — *Cicer arietinum* (seeds) — *Lathyrus sativus* (seeds) — *Tetragonolobus purpureus* (seeds) — *Ornithopus sativus* (seeds) — *Pisum sativum* (seeds) — *Glycine hispida* (seeds) — *Aesculus Hippocastanum* (seeds) — *Vitis vinifera* (seeds) — *Cornus sanguinea* (fruit) — *Ilex aquifolium* (seeds) — *Plantago major* and *P. media* (seeds) — *Galium Aparine* (seeds) — *Helianthus annus* (seeds).

SUBSTITUTES FOR COCOA: *Arachis hypogaea* (seeds) — *Glycine hispida* (seeds) — *Castanea sativa* (seeds) — *Cornus sanguinea* (fruit) — *Ligustrum vulgare* (fruit).

SUBSTITUTES FOR TEA. — *Rubus plicatus*, *R. nemorosus*, *R. caesius*, *R. idaeus* — *Fragaria vesca*, *F. moschata*, *F. grandiflora*, *F. chi-*

(1) KRAFFT, K., Ergebnisse der Untersuchung von Ersatzmittel für Nahrungs- und Genussmittel, in *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, vol. 33, No. 9, 1917.

For coffee and tea see also HASTERLIK, A., Kaffee und Kaffee-Ersatzstoffe; and Tee, Tee-Ersatzmittel, etc., Akadem. Verlagsgesellschaft, Leipzig.

(2) DIELS, op. cit., p. 222 et sq.

loensis — *Marchantia polymorpha*, etc. — *Asplenium ruta-muraria* — *Anthoxanthum odoratum* — *Salix* sp. — *Myrica Gale* — *Juglans regia* — *Betula* sp. — *Ulmus* sp. — *Urtica urens* — *Dianthus* sp. — *Ranunculus* sp. — *Cruciferae* sp. — *Sedum maximum* — *Ribes nigrum* — *Sorbus Aucuparia* — *Crataegus Oxycantha* — *Potentilla* sp. — *Alchemilla* sp. — *Agrimonia eupatoria* (fruit and leaves) — *Rosa Eglanteria* (leaves and fruit) — *Prunus Cerasus*, *P. spinosa* — *Melilotus officinalis* (flowers) — *Trifolium* sp. — *Anthyllis vulneraria* (flowers) — *Ilex aquifolium* — *Frangula Alnus* (bark) — *Tilia* sp. (flowers) — *Althaea* sp. — *Malva* sp. — *Hypericum* sp. (flowers) — *Viola tricolor* (plants, flowers and fruit) — *Epilobium angustifolium* — *Sanicula europaea* — *Coriandrum sativum* (aromatic fruits) — *Carum Carvi* (aromatic fruits) — *Pimpinella Anisum* (aromatic fruits) — *Foeniculum officinale* (aromatic fruits) — *Peucedanum Oreoselinum* — *Pyrola* sp. — *Vaccinium Myrtillus*, *V. Vitis-Idaea*, *V. Oxycoccos* — *Calluna vulgaris* (stems, leaves and flowers) — *Primula officinalis* (leaves and flowers) — *Fraxinus excelsior* — *Gentiana* sp. — *Pulmonaria officinalis* — *Lithospermum officinale* — *Lavandula spica* (flowers) — *Galeopsis dubia* (plant and flowers) — *Betonica officinalis* — *Melissa officinalis* — *Origanum vulgare* — *Thymus vulgaris* (plant), *T. Serpyllum* (plant) — *Mentha piperita* (plant) — *Veronica Beccabunga*, *V. montana*, *V. Chamaedrys*, *V. officinalis*, *V. prostrata-Alectorolophus* sp. (plant and flowers) — *Plantago* sp. — *Asperula odorata* (plant) — *Sambucus nigra* (flowers) — *Scabiosa* sp. — *Succisa* sp. — *Bellis perennis* (inflorescence) — *Antennaria dioica* (inflorescence) — *Achillea Millefolium* (inflorescence) — *Chrysanthemum* (*Tanacetum*) *vulgare* (inflorescence) — *Matricaria Chamomilla* (inflorescence) — *Tussilago Farfara* — *Carlina vulgaris* — *Centaura Cyanus*.

With regard to the plants, to the names of which no special indication is attached, the leaves are used, generally whilst still young.

SUBSTITUTES FOR TOBACCO (1): *Iris florentina* (the rhizomes for snuff) — *Valeriana officinalis* (roots).

Plants the leaves of which are used : *Sphagnum* sp. — *Salix* sp. — *Myrica Gale* — *Juglans regia* — *Corylus Avellana* — *Betula* sp. — *Fagus sylvatica* — *Quercus sessiliflora*, *Q. pedunculata* — *Ulmus campestris*, etc. — *Humulus Lupulus* — *Cannabis sativa* — *Urtica dioica*, *U. urens* — *Rumex crispus* — *Rheum officinale* — *Beta vulgaris* — *Berberis vulgaris* — *Nasturtium officinale* — *Platanus occidentalis* — *Prunus Cerasus*, *P. Mahaleb*, *P. spinosa* — *Rhus glabra* — *Aesculus Hippocastanum* — *Tilia* sp. — *Althaea officinalis* — *Archangelica officinalis* — *Arctostaphylos Uva-ursi* — *Cyclamen europaeum* — *Gentiana* sp. — *Symphytum officinale* — *Anchusa officinalis* — *Lavandula spica* — *Glechoma hederacea* — *Brunella* sp. — *Betonica* (*Stachys*) *officinalis* — *Salvia* sp. — *Thymus vulgaris*, *T. serpyllum* — *Plantago major* — *Asperula odorata* — *Sambucus nigra*, *S. racemosa*

(1) The majority of these substitutes are not used alone, but are mixed with tobacco. — The species mentioned were not all recommended or used in Germany ; some were used in Norway, Latvia, Austria etc.

— *Viburnum Opulus* — *Aster alpinus* — *Helianthus annuus* — *Achillea Millefolium* — *Tussilago Farfara* — *Arnica montana* — *Doronicum* sp. — *Senecio vulgaris* — *Cichorium Intybus.*

Plants the flowers of which are used for snuff : *Convallaria majalis* — *Rosa* sp. — *Melilotus officinalis.*

Fruits used as snuff : *Aesculus Hippocastanum.*

SUBSTITUTES FOR SPICES : — Ginger : *Acorus Calamus* (rhizomes); Cloves : *Geum Urbanum* (whole plant infused) ; Vanilla : *Picea excelsa* and *Abies pectinata* (the resin forms the raw material for the manufacture of artificial vanilla) ; Capers : *Caltha palustris* (flower-buds) — *Ficaria ranunculoides* — *Tropaeolum majus* — *Sarothamnus scoparius* — etc. ; Pepper : *Capsicum annuum* (fruit) — *Asarum europeum* (leaves).

Others are mentioned, but as they are of less importance they are omitted here for the sake of brevity : the following however mentioned by TROTTER (op. cit.) may be added : *Rhamnus prinoides* Her., R. *infusionum* Del. — *Catha edulis* Forsk. — *Abrus precatorius* L. — *Carissa edulis* Vahl. — *Salvadora persica* Garcin. — *Moringa oleifera* Lam.

In DIELS' treatis e from which the above information is taken, there are further groups of substitutes not directly connected with the subject of this work : the chapter headings only are given (1) : Substitutes for : MEDICINAL SUBSTANCES — SAPONACEOUS SUBSTANCES — RUBBER AND GUTTAPERCHA — RESINS — ESSENTIAL OILS — TANNING MATERIALS — FIBROUS MATERIALS — SILK — TIMFER.

8. — Dairy by-products and residues.

The by-product of most importance both in bulk and in the use to which it is put is skimmed milk, which has proved to be a very valuable food for young animals in conjunction with cattle cakes which supply the fats removed from the milk.

It is however used by man both with and without his knowledge, as it is fraudulently sold as whole milk or added to such milk instead of water.

Skimmed milk is used to make a poor kind of cheese and in the preparation of fermented foods such as yoghourt, kephir, etc.

It contains about 40 gm. of casein and 40 gm. of lactose per litre.

It is also used in the preparation of various fermented sweetened drinks called " milk lemonades " (Molkenlimonade), milk foam etc. A method of treating skimmed milk consists in curdling it by pressure or with an acid and then adding sugar to the separated whey, finally passing in carbon dioxide. In this way a refreshing and palatable drink is obtained.

(1) Cf. DIELS, L., op. cit. p. 274. and sq.

Other products made with whey in Germany during the war were those known as "Dr. Eichloff's Fleischersatz" and "Pyrmonter Nährwürze".

9. — Blood.

The blood derived from the slaughter houses is an offal which is employed in certain cases not only as a live stock feed and as a fertiliser but also as human food.

Pigs' blood and the blood, of poultry are used entirely for human food, but little use for this purpose was made of the blood of ruminants or horses till the war. Then owing to the shortage of animal food the blood of slaughtered animals of all kinds became much more largely used as food, whether after cooking, or by extraction of the serum for different purposes as will be explained further on. Meantime it is worth remarking that the blood of cattle has a food value nearly equal to that of beef of prime quality.

Blood serum was tried in Italy during the war for human food: *serum bread* (see p. 59) was made at Milan, and at Reggio Emilia the *Comitato per la disciplina dei consumi* in 1917-18 introduced this serum successfully into the components of soup pastes as a substitute for eggs.

Serum is also used instead of water in kneading bread in the proportion of one part of serum to three parts of flour.

For the manufacture of serum on a commercial scale, ALTANA (1), advises defibrinating the blood by whipping immediately after collection: then subjecting it to centrifugal action.

From a full grown ox 25 to 30 litres of blood yielding 15 to 20 litres of serum may be obtained, each litre of serum containing 75 gm. of protein matter in a dry state, *i. e.* as much as 15 eggs contain together.

Serum may also be used for cakes and other food products (macaroni etc.).

Horse blood, according to LINDET (2), may be treated in the same way as blood of cattle, and its serum can replace white of egg, as it contains 10 % of coagulated albuminoid, *i. e.* 2 % more than eggs. The blood is collected with the necessary attention to hygienic requirements, the fibre extracted by whipping, and the serum then allowed to settle so as to separate the globules. It can also be subjected to centrifugal action. Food made with this serum had an excellent taste. The difference between its price and that of white of egg was very considerable.

Bleeding a horse produced 20 litres of blood yielding 10 litres of serum equivalent to 200 eggs.

To obtain serum the blood of any slaughtered animal can be used, but it may be noted that the settling of the globules in the serum of

(1) Cf. ALTANA, Dr. G., in *Industrie Italiane Illustrate*, year IV, section D, No. 7. Milan, 1920, p. 25.

(2) Cf. *Comptes rendus de l'Académie d'Agriculture de France*, vol. IV, No. 29. Paris, 1918.

the blood of sheep or cattle or other ruminants takes longer than in the serum of horse blood.

To make the following statement complete it may be added that the albumen of coagulated blood keeps for some months in chloroform water containing 0.5 % of formaline solution. The chlorine that clings to this albumin is easy to remove (1).

Whole blood coagulated by heating also keeps a long time in a formaline solution. A large addition of sugar has also a preservative action, but for a shorter time.

Experiments made with dogs have proved that formalin taken into the system is less injurious than is supposed : only 0.6 % of the formalin so absorbed in the case of dogs and men has been found in the urine : all the rest has been oxidised during digestion.

The blood may be preserved for some weeks by adding boric or salicylic acid : it cannot then be used directly for human food, but its albumin may be so used in coagulated form prepared as usual.

The only way to keep blood so that it may be immediately and directly used for human food is by a large addition of sugar.

According to M. Salkowski, chloride of methyl might be used successfully to preserve blood, in the same way as it is used to preserve milk.

10. — Meat substitutes.

Few people can be found to believe it possible to produce by manufacture anything deserving the name of a real substitute for meat : yet during the war in the Central Empires there appeared among the innumerable food substitutes two meat substitutes called " Wurst " (sausage) and " Schnitzel " (cutlet). These consisted of a mixture of potatoes and yeast combined by an amorphous substance (paste) seasoned with a little pepper and coloured by a colouring matter extracted from coal-tar (2).

A substitute much more nearly resembling meat than these was one obtained by treating blood with chloride of lime and oxygenated water, which was called in Germany " Fleischersatz " (meat-substitute) and " Sparfleisch " (economy meat) (3). But this does not seem to have had a special importance, as it is simpler and more convenient to use blood as human food without preliminary transformation.

With fresh bones containing approximately 50 % water, 15 % fats, 12 % of nitrogenous substances and 22 % of ash, there was made in Germany and Denmark an extract sold under the name of " Fleisch-extract " (meat extract) and of " Knochenbrüherzeugnisse " (bone extracts) taking the form of a powder or a partially solid paste. A nu-

(1) Cf. Salkowski, E., in *Biochemische Zeitschrift*, No. 71,1915. — Summarised in *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, vol. 32, 1916.

(2) Cf. M. Mansfeld, Fleischersatzmittel, in *Berichte der Untersuchungsanstalt des allgemeinen Oesterreichischen Apotheker-Vereines* 1913-1915. — Summarised in *Zeitschrift für Untersuchung der Nahrungs und Genussmittel*, 15 April 1916.

(3) *Pharmazeutisches Zentralblatt*, vol. 57, 1916.

trient "Nährpräparat" made from this contained 6.62 % water, 25.76 % nitrogenous substances, 2.03 % fats, 57.2 % ash, 32.51 % lime and 23.97 % of phosphoric acid.

"Knochenbrüh-Würfel" (bone-extract cubes) were also prepared (1).

The best meat substitutes of vegetable origin are those prepared with dry yeast: when quite dry these contain 50 % of nitrogenous matter.

As other vegetable meat substitutes, there may be mentioned pea and bean flour, "Pflanzenfleischersatz" (*i. e.* vegetable meat-substitute) (2).

11. — Substitutes for table oils.

The oils whether for table use or otherwise that can be obtained from the various waste materials will be detailed in Part IV. Here mention will only be made of a substitute for salad oil illustrating the extent to which the manufacture of food stuff substitutes was carried by the Central Empires.

In Germany there was manufactured from the mucilage of Iceland moss (*Cetraria rangiferina*) a mixture called "Salathilfe Gloria" of which the component parts were this mucilage, powdered yolk of egg, benzoic acid, a yellow colouring matter and common salt (3).

In 1915-16 there appeared on the Austrian markets a number of so-called salad oil substitutes ("Salatöleerssatz", "Salatel", Salatöl", etc.), composed of an aqueous solution of mucilage of lichen preserved with boric acid and coloured yellow with an extract of coal tar (4).

In both cases then the mixtures contained no fatty substances and they might therefore be regarded as fraudulent.

They were however so much in demand that 12 kronen a litre was paid for them though their real value was not more than 50 heller a litre.

(1) Cf. Dr. Fr. Elsas, *Beiträge zur Kriegswirtschaft*, Part 29, Die Nährmittelverteilung im Kriege. Berlin, 1918.

(2) Cf. *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, vol. 34, 1917.

(3) Cf. A. Beythien and other authors: Mitteilungen aus der Praxis des chem. Untersuchungsamtes der Stadt Dresden, in *Zeitschrift für Untersuchung der Nahrungs- und Genuss-mittel*, vol. 32, 1916.

(4) M. Mansfeld, Oel-Ersatzmittel, in *Bericht der Untersuchungsanstalt des Allgemeinen Oesterreichischen Apotheker Vereines*, Vienna, 1915-1916. Reproduced in *Zeitschrift f. Untersuchung der Nahrungs- und Genussmittel*, vol. 33, 1917.

II. — FEED FOR LIVE STOCK

1. — Straw, Husks and Pods.

The *straw of cereals* ranks with forage that is poorest in albumin and richest in crude fibre (1). Spring cereals, owing to their short growth cycle, give better straw than winter cereals.

Stubble straw being mixed with weeds is a better forage than pure straw.

The *straw of leguminous plants* is much more nutritious than that of cereals, and is compared by KELLNER to clover hay of average quality, but since it is for the most part coarse, rather flavourless, and often musty, horses dislike it, so that it can only be used as a supplementary feed for cattle and sheep.

Among the leguminous straws suitable for the feeding of live-stock may be mentioned the straw of the garden bean, horse bean, vetch, lupin, chickpea, soy-bean, etc. (2).

Straw is also produced by other species of plants, rape, colza, sesame, camelina, poppy, buckwheat, caraway, anise, fennel, coriander, sunflower (3), etc.

Pea-straw is a good food for cattle, as has been shown by experiments made at the Agricultural Station of Washington, United States. It can be fed either alone, or mixed with lucerne hay, or maize silage. It was given to fully-grown cattle at the rate of 7.9 or 16 lbs. per day and per head. From these experiments, it appears that the value of pea-straw is about 30 % less than that of lucerne straw (4).

Pea-straw is one of the best leguminous straws (5), and was used like others in Germany during the War in the form of forage meal. It contains according to KLING: water 11.2 % — crude protein 7.5 % — crude fat 1.1 % — N-free extracts 39.2 % — crude fibre 35.5 % — crude ash 5.5 %.

Horse-bean straw. — If harvested when still green, this straw may be compared with a rather inferior hay; its value is greatly reduced if it is allowed to turn yellow and dry by standing (4). In the first case, it contains: water 10.5 % — crude protein 12.6 % —

(1) Cf. O. KELLNER, *Principes fondamentaux de l'alimentation du bétail,* Librarie Berger-Levrault, Paris, 1911, p. 125.

Cf. also CH. CORNEVIN, *Des Résidus Industriels dans l'Alimentation du Bétail,* Paris, Firmin-Didot et C.

(2) M. A. CROSBY, The utilization of Pea-cannery refuse for forage. *U. S. Dep. of Agr. Bur. of Plant Ind. Circular,* No. 45. Washington, 1910.

(3) Detailed information regarding all these straws will be found in Manual of Stock-Feeding, E. POTT'S, p. 394 et sqq. (ital. ed. 1-3 vol., Torino, 1907).

(4) Cf. *Breeders' Gazette,* vol. 77, No. 15. Chicago, 1920.

(5) Cf. KLING, Dr. MAX. *Die Kriegsfuttermittel.* Stuttgart, 1918, E. Ulmer, p. 52.

crude fats 1.6 % — N-free extracts 31.2 % — crude cellulose 29.3 % — crude ash 14.8 %.

Rice straw is generally used for litter, being not very good as a stock feed, although it can be much improved if it is dried directly after the harvest and put in the silo with half-dried grass. After about one month in the silo, it can be fed mixed with concentrates. This silage keeps for several months (1).

Potato haulms (2). — When these are still green, they make fair forage, but lose much of their value as soon as they begin to turn yellow, and become worthless if allowed to become dry by standing. In many places, potato haulms are regarded as practically useless, and are left to rot on the ground or at best thrown on the manure-heap. During the war however they were turned to better account, especially in Germany, where enormous quantities are produced.

It should, however, be remarked that these stems cannot be fed green to live stock, as the animals would refuse them, but require to be silaged or dried in the air. According to 3 analyses by Dr. MEYER, potato haulms contain: water 8.6 % — crude protein 13.7 % — crude fat 2.9 % — N-free extracts 38.1 % — crude fibre 17.8 % — crude ash 18.9 %.

When given experimentally to dairy cows and sheep, at rate of 4-5 kg. per head per day the digestibility coefficients of these haulms were as follows: organic matter 64 % — crude protein 57 % — fat 53 % — N-free extracts 68 % — crude fibre 66 % — starch value 34-36.

Ground potato leaves make a good pig-feed.

Flax stems. — These are the stalks of flax after the leaves have been removed. They are useless as a stock feed, for they are generally refused by the animals, and also their high crude fibre content reduces their nutritive value almost to nil. They contain, according to FILKER (3): water 11.6 % — crude protein 2.3 % — crude fat 0.6 % — N.-free extracts 21.4 % — crude fibre 62.8 % — crude ash 1.3 %.

The *Husks* are generally richer than the corresponding straw. The best cereal husks are those of oats and barley, after which come wheat husks; rye husks are very indigestible, while the husks of rice and of millet have no alimentary value.

Husks should always be boiled before being fed to stock, as amongst other reasons the heat destroys the spores of injurious micro-organisms such as *Actinomyces bovi.*

The crude fibre of the husks is more or less mixed with investing substances; it is digested more easily by sheep than by pigs which do better on fibre that is but little lignified. The better digestion of crude fibre by sheep is probably due to the fact that ruminants grind up the husks more thoroughly during mastication and rumination, while

(1) Cf. KLING, Dr. M. Op. cit., p. 18.
(2) Cf. *Il giornale di Risicoltura*, vol. X, No. 9. Vercelli, 1920.
(3) Cf. KLING, Dr. M. Op. cit., p. 52.

the food undergoes more intense fermentation in their digestive system (1).

The *Pods* of peas, vetches, garden beans and lupins have the same food value as inferior red clover or meadow hay of ordinary quality. Lentil and clover pods have a higher food value. The pods of colza, camelina, mustard and buckwheat and the capsules of flax are less digestible than cereal husks. Ground-nut pods and the " hulls " of coffee-beans, to which reference will be made later, have hardly any food value.

Garden bean pods were used as a forage in Germany during the war, especially for pigs ; they must not be fed in large quantities as they induce constipation.

Honcamp gave these pods to a lamb in order to determine their digestibility ; the results obtained were as follows : 89.2 % of the organic matter, 70.5 % of the crude protein, 72.9 % of the fats, 89.5 % of the N-free extracts and 94.5 % of the crude fibre was available. It should be observed that although there were large quantities of crude fibre present, its digestibility was fairly high. The percentage composition of the bean pods and bran (by-products obtained by grinding) is as follows :

	Garden bean pods	Garden bean bran
Water	10.5 %	10.1 %
Crude protein	10.1	13.7
Fats	0.7	1.8
N-free extracts	45.4	52.5
Crude cellulose	30.2	18.2
Ash	3.1	3.7

Mach (2) suggests that the large quantities of *pea-pods* forming the residues from vegetable canning factories could be dried and made into a stock-feed. When dry, these pods contain : water 14 % — crude protein 14.8 % — crude fat 0.9 % — N-free extracts 50.6 % — crude fibre 15 % — crude ash 4.7 %. The starch value of the freshpods is 8.4, and that of the dried pods is 45-46 (3). These pods are especially suited for cattle and pigs.

Air-dried *Ground-nut pods* (4) contain 89.93 parts of dry matter : 2.6 parts crude protein — 2.9 parts fat — 7.2 parts N-free extracts — 2 parts fibre and 14.7 parts organic matter. As has been already said,

(1) Cf. *Die Landw. Versuchs-Stationen*, Vol. LXXXIII, Parts 3-4. Berlin, 1913.

(2) Cf. *Landwirtschaftliche Presse*, No. 43, Berlin, 1916.

(3) Cf. Kling, Dr. Max. Op. cit., p. 24, 124.

(4) Cf. Ferrera Dr A., Prodotti dell'Arachide e loro utilizzazione, in *L'Agric. Colon.*, No. 3, Firenze. 1923. p. 97.

they have no food value but were sold finely ground during the war in Germany under the name of groundnut bran ("Erdnusskleie") at 24 *marks* per kg. 100. According to KELLNER, the digestibility coefficients of this substance are as follows: crude protein 36 % — fat 96 % — N-free extracts 39 % — crude fibre 3 % — starch value 0.1.

"Red bran" and "fat bran" are richer products obtained from the ground-nut-oil industry. The first is made from the integuments of the seed, which are removed by some manufacturers in order to produce a finer oil. For the same reason, and to secure a very white product, the germs are removed from the seeds. The nutritive value of this residues is very high; if the bran is pure, the nitrogen content may be as much as 24 % and the fat content 20 %.

Coffee hulls are a mixture of the outer integuments (90 %) and the inner integuments (10 %) of the seeds. They are used in Germany for the preparation of a molasses feed, and contain a large amount of fibre (71.76 %). When air-dried, their dry matter content is 88.73 %: crude protein 0.2 % — traces of fat — 2.6 % N-free extracts, — 7.8 % organic matter — 10.6 % crude fibre.

Coffee hulls, like peanut pods, can be used for fuel (1).

Cacao hulls. — Are also unsuitable for a stock feed, and may be compared to the straw of winter cereals.

When air-dried, they contain 90.93 % dry matter composed of: 0.7 % crude protein — 6.9 % fat — 22.1 % N-free extracts — 2.8 % crude fibre and 32.5 % organic matter (1).

DE MARNEFF'S analysis is however somewhat different being: water 13.24 % — nitrogenous matter 11.08 % — fats 2.9 % — N-free extracts 46.71 % — fibre 16.03 % — mineral substances 10.04 %.

When the cacao hulls have not undergone any alteration, they can be soaked in water and added to the basic ration of cows in quantities of 0.6 to 1 kg. per day (2). Cacao hulls (the perisperm of the seed) have also been examined at the Municipal Laboratory of Le Mans (France) with the result that they are considered dangerous, especially for horses etc., on account of the theobromine they contain. On the other hand, if the cacao-hulls are freed from the extractive substances (with a view to the preparation of theobromine and of extracts for use in confectionery and the manufacture of malt coffee) they have no longer any food value (3).

Horse-poisoning by cacao hulls has also been reported by FONZES-DIACON: a ration of 700 of these hulls contains 0.7 % theobromine, a substance by which horses are easily affected (4).

Cacao hulls, when fed by RICHARDSEN to dairy cows in a comparative experiment, at the rate of four parts in 10,000 of live weight decreased the milk yield about 15 %, as compared with the amount obtained by feeding barley.

(1) Cf. I. FRITSCH. Op. cit., p. 226.
(2) Cf. P. RAZOUS. Op. cit., p. 333.
(3) Cf. *Annales des Falsifications et des Fraudes*, Year XIII, Nos. 131-132. Paris, 1919.
(4) *Ibidem*, Year XIII, No. 135-136. Paris, 1920.

As the sale of pure flour of cacao hulls is forbidden in Germany (1), to prevent its use in adulteration of human food, it is now mixed either with straw or hay (3 parts), or with cereal or buckwheat husks (5 parts) and in this form can be sold for feeding live-stock.

For ruminants, the digestibility of the crude protein in cacao hulls is only 15 %, whereas the availability of the fat is 84 % and that of the N-free extracts and crude fibre 48 % and 21 % respectively. The starch value is 34, so these hulls can be compared to meadow hay.

Since cacao-hulls cause constipation, they must be fed sparingly and mixed with molasses.

Their chemical composition according to KLING is as follows :

Water	11.7 %
Crude protein	16.1
Crude fat	2.4
N-free extracts	43.7
Crude fibre	17.4
Ash	8.7

In Germany, during the war, a stock feed called " Kakaomasse " was put on the market. It consisted of a mixture of cacao hulls with the residues of the seed itself and a little straw, and contained according to KLING : water 12.4 % — crude protein 248. % — crude fat 3 % — N-free extracts 40 % — crude fibre 9.6 % — mineral substances 10.2 %.

A recent series of experiments made at the *Istituto Zootecnico di Lucento* (Lucento Stock-Breeding Institute), Turin, by the Director Prof. V. VEZZANI (2) have shown that :

1) The hulls of cacao are readily eaten by pigs, provided they are fed in small amounts 5-6 %.

2) They give a pleasant flavour of chocolate to the ration.

3) Given in the above quantities, they do not in any way hinder the increase in live-weight, or the fattening of young pigs.

4) If cacao hulls form more than 10-12 % of the ration, they produce distaste and nausea, while if the amount is increased to 16 % and over, serious disturbances of the digestive system and even death result. The subject however is worth further investigation, for there was nothing to show that the death of the pigs used in these experiments was due to theobromine.

The author suggests that, as a matter of precaution, pigs rations should never contain more than 5-6 % of cacao hulls which ought to be chiefly used to improve the flavour of other foods and make them more appetising.

(1) 1) KLING, Dr. MAX, op. cit, p. 47 ; 2) *Berliner Tierärztliche Wochenschrift*, Year 38, p. 333. Berlin, 1922.

(2) V. VEZZANI. L'uso alimentare delle bucce di cacao nell'alimentazione dei suini. *Ist. zoot. di Lucento* (Turin), 1922. — See also, EBERHARD, *Berliner Tierärztliche Wochenschrift*. Year 38, No. 29. Berlin, 1922.

The *Pods of the wild radish*, or white charlock (*Raphanus Raphanistrum*) (fig. 1) frequently occur in wheat screenings. According to KLING, their nutritive value is 40 % of that of a good forage barley. They are good for cattle and horses but are unsuitable for swine. These pods contain: water 6.90 % — crude protein 10 % — fats 6.78 % — N-free extracts 43.32 % — crude fibre 30.40 % — ash 2.60 % (1).

In Germany, some of the residues of this order have been used in preparing compound feeds, such as (2):

a) *Husks of spelt* ground and mixed with gelatine, buckwheat flour and condiments. Their nitrogenous substances are fairly digestible, but the availability of the other components is below 4 %.

Spelt husks are ground and sold in Germany under the names of "Spelzspreumehl", "Spelzmehl", or "Futterfeinmehl". From 3 analyses of this product the following averages have been obtained: water 8.6 % — crude protein 3.2 % — crude fat 0.86 % — N-free extracts 45.8 % — crude fibre 34.8 % — mineral substances 7 %. The digestibility of these husks is very low and is not improved by grinding. They cause irritation of the oesophagus and coughing in horses but these troubles can be prevented by feeding the husks as a hot mash (3).

FIG. 1. — Wild radish.

From Dr. A. FIORI. Iconographia Florae-Italicæe. Padova 1895-1904.

b) *Involucres of seeds of sugar-beet.* — These are very rich in non-digestible cellulose and are unsuitable for livestock.

c) *Ground pods of beans* (*and other leguminosae*). — These contain a large amount of non-digestible fibre. As a rule, the pods of leguminosae have a composition and availability similar to those of the straw of these plants, but they contain a little less fibre, and a little more protein. Their percentage composition, according to GUILLIN, is as follows: water 11.76 % — protein 6.68 % — fat 0.34 % — carbohydrates 43.22 % — fibre 34.84 % — mineral substances 3.16 %.

Finely ground clover and lucerne hay contain from 7 to 8 % crude protein, of which about one half is digestible (4).

The *Pods of the guango* (*Inga Saman*) have been used in experi-

(1) Cf. *Landw. Jahrbuch für Bayern*, No. 11-12. Munich, 1916.

(2) Cf. *Die Landwirtschaftlichen Versuchs-Stationen*, vol. XCVI, Parts 5-6, 1919; Vol. XCVII, 1920.

(3) KLING, Dr. MAX. Op cit., Chapt II, p. 40.

(4) Cf. A. MENOZZI and V. NICCOLI, *Alimentazione del bestiame*. Milan, Hoepli 1910, p. 219.

ments in Jamaica, 15.5 to 26.5 lbs per head per day having been fed to cows without any bad results.

These pods are very rich in sugar and are astringent, fermenting readily. They are fed mixed with maize stalks, or *guango* bagasse, the whole mixture being first dried for several hours at 65.5° C (1).

Integuments of cotton seeds. — These consist of the seed coat which is separated from the albumin before the extraction of oil. They are used ground, as a stock-feed, fertiliser, or for fuel.

Integuments of horse beans (2). — These are separated from the albumen in the factories making dried vegetables for soups. They are mixed with the embryos and ground; the bran thus obtained is an excellent feed, especially for dairy cows and pigs. Only a small quantity should however be given to pigs as the integuments contain oxalic acid. Their average content is: dry matter 89.8 % — nitrogenous matter 45 %, fat 1.4 % — N-free extracts 37 % — crude fibre 44.8 % — ash 2.1 %.

Buckwheat residues (2). — Buckwheat bran consists of the hulls, *seed integuments* and *embryos*, plus the particles of flour. It is a feed of little value. Buckwheat forage meal without the hulls is much more nutritious, as it consists chiefly of embryos and the seed flour. It may contain: dry matter 87 % — nitrogenous substances 20.6 % — crude fat 5.2 % — N-free extracts 55.4 % — crude fibre 2.8 % — ash 3 %. It is excellent, especially for swine, draught-horses and poultry, but should always by fed in moderation: its excessive use induces the disease called *fagopyrism*.

According to HONCAMP and BLANCK (3) the following percentages were obtained from a digestibility experiment carried out on sheep with buckwheat integuments: crude protein 6.6 % — fats 100 % — N-free extracts 24.7 % — crude fibre 8.3 % — starch value of airdried integuments: 2 kg. per 100 kg. — digestible albumen 0.1 %. This residue is thus of little value as a food. HONCAMP and BLANCK found its dry matter contains: crude protein 3.6 % — crude fat 3.6 % — N-free extracts 45.7 % — crude fibre 48.9 % — mineral substances 1.3 %.

FIG. 2. — Black Medicago.
From Dr. A. FIORI, op. cit.

Pods of black medicago (*Medicago lupulina*) (fig. 2) (4). — In Germany, these were put on the market as a war stock-feed

(1) Cf. *The Journal of the Jamaica Agricultural Society*, Vol. XXIV, Nos. 6-7. Kingston, 1920.
(2) Cf. POTT, E. Op. cit., Vol. III, pp. 241-242.
(3) Cf. KLING, Dr. Max. Op. cit., p. 42.
(4) Cf. KLING, Dr. MAX. Op. cit., p. 43.

(" Kriegsfuttermittel "). According to HONCAMP and BLANCK they contained: crude protein 16.7 % — pure albumen 16.1 % — crude fat 2.3 % — N-free extracts 46.9 % — crude fibre 26.3 % — mineral substances 7.8 %.

According to these authorities, the following percentages were obtained from digestibility tests made on a sheep: crude protein 49.9 % — fats 51 % — N-free extracts 47.1 % — crude fibre 68.5 % — starch value of air-dried material 36.2 % — amount of digestible albumin 6.6 %.

This may be compared to good meadow hay and used in the same manner. Only a little should be fed to swine, and never uncooked.

FIG. 3. — Common Sawwort.

From Dr. A. FIORI, op. cit.

FIG. 4. — Wild Rape.

From Dr. A. FIORI, op. cit.

Husks of common sawwort (*Serratula tinctoria* L.) (fig. 3) (1). — This perennial Composita which is both a forage and a dye plant, bears husks of the following composition, as analysed by the Agricultural Station of Köslin: water 19.3 % — crude protein 19.6 % — crude fat 2.4 % — pure protein 18.2 % (7.4 % of which is digestible) — N-free extract 26.5 % — crude fibre 22.6 % — ash 9.6 % — starch value 30. These husks are comparable as a feed to good red clover hay. After cooking they are especially suitable for milch cows and nursing-sows.

Pods of wild rape (*Brassica Napus oleifera* L.) and of *Wild Turnip* (*B. Rapa* L.) (fig. 4) — These were of great importance during the war, in Germany (2). The chemical composition of wild rape pods is as follows according to HONCHAMP and BLANCK: crude protein

(1) Cf. KLING, Dr. MAX. Op. cit., p. 44.
(2) Cf. KLING, Dr. MAX. Op cit., p. 43.

11 % — pure protein 10.2 % — crude fat 8.5 % — N-free extracts 39 % — crude fibre 25.8 % — pure ash 15.7 %.

A digestibility test carried out on a sheep gave: crude protein 52.2 % — fat 86.2 % — N-free extracts 53.4 % — crude fibre 54.8 % — starch value 31.9 kg. per 100 kg. of air-dried material — digestible albumin 4.3 %. Thus these pods are of more value than wheat husks. In many places they are fed to horses instead of straw.

Flax capsules. — These have long been used, when ground, as a stock feed.

During the war, a feed was imported from Holland into Germany, under the name of "ground flax capsules", or "flax bran", though "flax husks" ("Leinspreu") would have been a more correct appellation.

KLING (1) made an analysis of a coarsely ground mixture of flax capsules with a few leaves and stalks.

According to KELLNER, the capsules contain: water 11.6 % — crude protein 3.5 % — crude fat 3.4 % — N-free extracts 35 % — crude fibre 40.7 % — mineral substances 5.8 % — digestible albumin 1 % — starch value 17.7.

These capsules have about the same value as cereal husks. When ground and mixed with boiled potatoes, they form a good pig food.

Poppy capsules. — These residues, which are dangerous because of the alkaloids they contain, were also sold as a feed in Germany during the war. Sometimes the capsules alone were put in the market, at other times, they were mixed with mineral impurities, weed-seeds, and oil-factory residues, but they were usually sold under names that disguised their true origin, such as: residues of oleaginous seeds ("Oelsaatabfälle"), bran of oleaginous seeds ("Oelkleie") etc.

Use proved these residues to be poisonous.

Integuments of acorn. — The albumin alone of these seeds is employed in the manufacture of coffee, leaving as a residue the integuments, which when dried and ground have been recommended as a stock-feed.

Their percentage composition according to E. MULLER is as follows:

Water	7.7 %
Crude protein	3.6
Crude fats	2.8
N-free extracts	41.4
Crude fibre	41.8
Crude ash	2.7

Acorn-integuments therefore have a very low nutritive value as compared with cereal husks.

Apricot and Peach kernels and Walnut shells. — KLING (2) analysed a food sold as a substitute for cereal husks; it was a flour made of apricot and peach kernels (82 %) and walnut shells (18 %)

(1) Cf. KLING, Dr. MAX. Op cit,, p. 45.
(2) Cf. KLING, Dr. MAX, Op. cit., p. 48.

It contained: water 9.6 % — crude protein 4.6 % — crude fats 1.5 % — N-free extracts 60.1 % — crude fibre 22.2 % — mineral substances 2 %.

This food may be given to cattle and horses but not to pigs. Before feeding, it should be well soaked in water, in order to prevent the presence of any hard particles that might cause abrasions in the digestive organs.

Residues of sunflower heads. — After removing the seeds, the large sunflower heads are generally thrown on the manure heap. During the war, it was suggested in Germany that they might be used for human food, but as was only to be expected they found no purchasers. They can however be used as a stock-feed, if dried and ground, mixed with a little oil-cake or other substance rich in protein. Sunflower heads can be silaged after being chopped, but such silage soon decomposes when once the silo is opened.

According to KLING (1), these residues contain: water 89 % — crude protein 0.7 % — crude fat 0.4 % — N-free extracts 7.3 % (0.035 % tannic acid and 2.3 % sugar) — crude fibre 1.6 % — ash 1 %.

Sunflower stems when chopped and treated with steam for 3 to 4 hours can be satisfactorily fed to pigs. Their nutritive value is higher than that of cereal straw, as is shown by their composition: water 7.8 % — crude protein 9.8 % — crude fat 0.7 % — N-free extracts 34.8 % — crude fibre 33.8 % — crude ash 13.1 %.

The three following tables are taken from POTT (op. cit., Vol. II), who obtained the data from the results of the analyses of various authors.

Table I gives the average percentages of the nutritive substances present in some ordinary kinds of husk. Table II gives the same data for the pods of common pulse plants.

(1) Cf. KLING, Dr. MAX, Op. cit., p. 35.

TABLE I. — *Percentages of nutritive substances in different kinds of husks.*

Species	Dry matter	Nitro-genous matters	Fats	N-free extracts	Crude fibre	Ash
Red clover	85.7	17.2	1.4	33.8	23.1	10.2
White »	88.6	18.4	3.1	36.8	22.4	7.9
Black Medicago (*Medicago lupulina*)	86.2	20.7	2.2	30.8	21.9	10.6
Bird's-foot Trefoil (*Lotus corniculatus*)	84.0	16.4	3.6	33.7	21.8	8.4
Serradilla (*Ornithopus sativus*)	—	—	—	—	—	—
Oats	86.0	50.0	2.6	40.0	27.9	10.5
Wheat	86.0	4.5	1.7	38.2	30.7	10.9
Spelt	85.7	3.2	1.3	32.1	40.7	8.4
Rye	86.0	4.6	2.0	28.4	43.5	7.5
Barley	85.8	3.1	1.5	38.5	30.3	12.4
Dari (*Sorghum tartaricum*)	89.9	3.7	0.9	53.3	24.3	7.6
Rape and Colza	87.0	3.8	1.8	38.0	37.0	6.4
Flax	86.6	5.1	3.7	34.0	35.9	7.9
Camelina (*Camelina sativa*)	88.8	2.7	1.1	32.6	45.2	7.2
Buckwheat	86.8	4.6	1.1	35.3	43.5	2.2
Maize stripped stalks	87.8	2.9	0.8	45.3	36.9	1.9

TABLE II. — *Percentages of nutritive substances in the Pods of different Pulse plants.*

	Lentils	Horse beans	Peas	Lupins	Soy-beans	Vetches
Dry matter	85.0	85.0	86.0	87.3	89.2	85.7
Nitrogenous matter	18.4	10.6	10.8	9.0	6.0	10.4
Crude fats	1.8	1.5	2.0	0.7	1.5	1.7
N-free extracts	37.4	29.3	34.0	42.4	43.0	32.9
Crude fibre	19.5	36.2	32.0	29.2	30.4	31.9
Ash	7.9	7.4	7.2	6.0	8.3	8.8

Basing our calculations on the world's statistics of the chief cereals (1) to which reference has been made, an estimate can be made of the total average residues from each by taking their average straw yield per acre as: wheat 2 metric tons — oats 2 metric tons — rye 1.8 metric tons — barley 2 metric tons — rice 2.5 metric tons — maize 3 metric tons.

(1) Cf. International Institute of Agriculture, *International Year-Book of Agricultural Statistics*, 1917-1918. Rome, 1920.

Quantities of Straw produced by the different Cereals in the two Hemispheres. Average of 1909 *to* 1918-1919.

Cereals	Area in acres	Annual straw-yield in tons
Wheat	268,073,359	216,967,702
Rye	103,170,224	75,151,615
Barley	78,251,740	63,333,784
Oats	139,149,648	112,622,080
Maize	155,585,984	188,887,476
Rice	108,777,278	110,049,895
Total	853,008,233	767,012,552

Taking these quantities into consideration, together with the fact that a large part of their residues remain unused on the ground (which is in itself no actual harm), some idea can be gained of the advantage that might have resulted from their careful use either as forage, or fertilisers. In order to determine the value of these residues as stock-feeds, it is necessary to consider their average content of digestible elements as given by KELLNER (see Part II, No. 44), and by basing calculations on the total world production, the total quantitites of digestible nutritive elements contained in the various straws will be found: these are given in the following Table.

Crops	Total straw of Northern and Southern Hemispheres — Average 1909-1919 — metric tons	Crude albumin metric tons	Crude fats metric tons	N-free extracts metric tons	Crude fibre metric tons
Wheat	216,967,702	433,935 0.2 %	867,871 0.4 %	28,856,704 13.3 %	44,261 411 20.4 %
Rye	75,151,615	450,910 0.6 %	300,607 0.4 %	9,694,558 12.9 %	16,533,355 22 %
Barley	633,333,784	443,337 0.7 %	253,335 0.4 %	8,043,391 12.7 %	13,300,095 21 %
Oats	112,622,080	1,464 087 1.3 %	563 110 0.5 %	18,582,643 16.5 %	23,538,015 20.9 %
Maize	188,887 476	3,211,087 1.7 %	944,437 0.5 %	32,488,646 17.2 %	44,388,557 23.5 %
Rice	110,049,895	2,751,247 2.5 %	1,100,499 1.0 %	11,775,339 10.7 %	22,120,029 20.1 %
Totals	**1.337,012,552**	**8,354,603**	**4,029,859**	**109,341,381**	**164,141,462**

2. — Disintegration of Straw (1).

With a view to improving the digestibility of the straw of winter cereals, especially wheat straw, several processes have been proposed and tested (chiefly in Germany) by which the availability of the straw might be increased by treating it so as to liberate the fibre from the investing substances, especially lignin and silica, in order to facilitate the action of bacteria in bringing about its decomposition and disintegration. In these processes, it is not necessary to eliminate the lignin entirely, but merely to soften the fibrous portions and thus break the bond between the lignin and the cellulose.

Satisfactory results were obtained from treatments with alkaline lyes of caustic soda and carbonate of soda, and also with milk of lime. Acids on the other hand only gave negative results.

Treatment with caustic soda lye. — The method that proved most satisfactory was BECKMANN'S, in which the straw was treated cold with alkalis.

The feeding experiments made by HONCHAMP with straw treated by the BECKMANN process have shown that destruction takes place of part of the organic mater containing all the group of nutritive substances.

Treatment with 3.5 % and 7 % caustic soda increased the digestibility of winter cereal straw 72 % and 94 % respectively.

In conclusion, the increase in the starch value due to disintegration was considerable in the straw of winter cereals, but slight in straw from Leguminosae and Cruciferae.

The BECKMANN process is carried out in the following manner by the " Veredelungsgesellschaft für Nahrungs- und Futtermittel, Bremen and Berlin ":

The straw is chopped and placed in flat boxes made of wood or tin (the fixed height being 50 cm; the surface area, 2 sq. metres per kg. 100 of straw): 8 times its weight of 1.5 % — 2 % of soda lye is then added and allowed to work for 12 hours; the mixture should be stirred from time to time. Afterwards the straw is washed.

(1) Cf. 1) HONCAMP, F., Über Strohaufschliessung, *Die landwirt. Versuchsstat.*, vol. XCV, Parts 1-3. Berlin, 1919. — 2) HANSEN J., Die Aufschliessung von Stroh mit Kalter Natronlauge nach dem Verfahren von Beckmann, *Mitteil. der Deutsch. Landw.-Gesell.*, vol. XXXIV, Part 4. Berlin, 1919. — 3) MAGNUS H., Theorie und Praxis der Strohaufschliessung. Berlin, P. Parey, 1919. — 4) HONCAMP F. and BAUMANN F., Untersuchungen über dem Futterwert des nach verschiendenen Verfahren aufgeschlossene Strohes. II. Mitteil.: Aufschluss des Strohes durch Ätzkalk mit und ohne Druck. III. Mitteil: Aufschluss des Strohes mit Soda. *Die landw. Versuchsstat.*, Vol. XCVIII, Parts 1-2. Berlin, 1921. — 5) VON WISSEL, Beitrag zur Ermittelung eines einfachen und zuverlässigen Verfahrens die Höhe des Aufschliessungsgrades von Kraftstroh und desgleichen analytisch festzustellen. *Die landw. Versuchsstat.*, v. XCII, Parts 5-6. Berlin, 1921. — 6) WEISER S. and ZEITSCHEK A., Über Stroh aufschliessung. *Die landw. Versuchsstat.*, vol. XCVII, parts 1-2. Berlin, 1920. — 7) KLING dr. MAX, op. cit., p. 51 et sqq. — 8) GRÉGOIRE A. La Désagregation des Pailles. *La Vie Agr. et Rur.*, No. 36. Paris, 1922.

FINGERLING has compared this cold lye method with COLSMANN boiling lye method. He obtained the following results.

Nutritive substances	Straw disintegrated by COLSMANN process	Straw disintegrated by BECKMANN process	
		for 3 days	for 12 hours
Organic matter	58.77 %	72.76 %	71.08 %
N-free extracts	35.89	79.59	63.55
Fat	—	69.01	84.76
Crude fibre	73.28	70.36	78.86

The plant installed by HANSEN at the Agricultural Institute of the University of Königsberg for the purpose of testing the BECKMANN process showed that the average water consumption is 4.02 cubic-metres per 100 kg. of dry straw; this gives 410 kg. of disintegrated straw containing on an average 16.9 % of dry matter. The loss in dry matter was 22.4 % as against 37.16 % with the COLSMANN process.

It takes 20.8 litres of cold soda lye but only 16 litres of boiling soda lye to disintegrate 100 kg. of straw.

HANSEN also compared the effect of the two processes from the standpoint of the immediate composition of the product and obtained the following results:

Nutritive substances	Straw disintegrated by cold lye (BECKMANN process)		Straw disintegrated by hot lye (COLSMANN process)	
	for 3 days	for 12 hours	for 3 days	for 12 hours
Dry matter	16.29 %	16.81 %	100.00 %	100.00 %
N-free extracts	4.18	4.36	25.59	27.57
Crude fat	0.18	0.19	1.10	1.11
Crude fibre	6.66	6.44	40.93	38.32
Starch value	9.50	9.72	58.32	57.79

HANSEN has observed that horses prefer straw that has been disintegrated with cold lye. In the case of milch cows fed for 3 months on straw treated by both methods, the variations in the milk yield and fat production obtained from straw disintegrated with cold and boiling lye respectively were very slight (1).

Treatment with milk of lime both with and without pressure. — The experiments of HONCAMP and BAUMANN have demonstrated

(1) The liquid derived from the treatment of straw with alkalis, if neutralised with mineral acids, or aluminium or calcium salts, produces a precipitate which when separated by decantation and kept moist can be used as glue. (Cfr.: KOLLER Dr. TH., op, cit., p. 440).

that the disintegration of straw by milk of lime also causes greater losses in organic matter when the process is carried out under pressure than when no pressure is applied. The fibre does not appear to be attacked.

Milk of lime removes less of the investing substances than are removed by caustic soda, but the quantity of organic matter is almost the same in either case, so that the amount of lignin present in a disintegrated straw is not an exact measure of the degree of disintegration.

The starch value of straw disintegrated by milk of lime is much higher than that obtained by the soda method: 48.68 as against 13.29.

Straw disintegrated by milk of lime was readily eaten by stock and no digestive disturbances were observed.

Disintegration of Straw with carbonate of soda. — The straw is treated in the same way as in the preceding methods, being boiled for 3 hours with 8 times its weight of an 8 % solution of carbonate of soda. The cellulose is not attacked at all, but the pentosans are probably much affected. This method is in no way inferior to treatment with caustic soda lye.

A comparison between rye straw disintegrated by boiling for 5 hours with 8 % milk of lime without pressure, and the same straw disintegrated with carbonate of soda of the same concentration, but boiled for a shorter time, has shown that the latter process is more effective, as may be seen from the following digestibility coefficients.

	Straw disintegrated with milk of lime	Straw disintegrated with carbonate of soda
Organic matter	53.4 %	60.6 %
N-free extracts	32.2	41.0
Crude fibre	75.7	80.2
Starch value	47.1	55.6

Analytic determination of the extent to which the Straw has been disintegrated. — The following tests were applied: 1) phloroglucin test; 2) WEENDE'S method; 3) gravimetric method; 4) volumetric method; 5) WOHL'S calcium chloride method. The results show that in order to determine the changes which have taken place in straw treated with caustic soda lye, the straw must be analysed before and after treatment and further, the disintegration process adopted must generally be known.

VON WISSEL describes briefly 3 hitherto untested processes invented by: — WAENTIG and GIERSCH — MACH and LEDERLE — WILLSTÄDTER (1).

(1) Cf. *Die Landwirtschaftlichen Versuchs-Stationen*, Vol. XL. Berlin, 1917.

WEISER and ZEITSCHEK made comparative experiments in Hungary during the war with the BECKMANN and LEHMANN processes. The latter consists in treating the straw with a boiling lye of caustic soda for 4 hours under a pressure of 4 atmospheres. The digestibility of the crude fibre and N-free extracts was increased by this process 12-13 % and 25 % respectively. For each 100 kg. of straw, 200 litres of water containing 1.5 kg. of 96 % caustic soda were added. The food thus obtained was tasty, had an appetising smell and owing to the formation of acetic acid a decidedly acid reaction. Its nutritive value, always allowing for the absence of digestible albumin, is equivalent to the nutritive value of good hay. In fact, its starch value is increased from 56-77 by this process. By using an autoclave of 14 cubic metres, these authors obtained sufficient disintegrated straw for 200 head of fully grown cattle.

They also treated the straw with a caustic soda lye (8.40 kg. in 240 litres of water per 100 kg. of straw) for 6 hours under ordinary pressure, but found that the long washing necessitated by the strong concentration of the caustic soda removed a large amount of the dry matters, while the digestibility of the crude fibre was but little increased.

The same investigators also tried treating straw with steam alone, or with steam and lye together. In the first case, the digestibility was considerably increased, but not to the same extent as in the combined treatment. The straw when merely steamed, was stiffer and less appetising, as well as less economical of nitrogen than when also boiled in soda lye.

They also obtained good results by treating the straw with milk of lime, but the straw required washing thoroughly afterwards.

In conclusion, straw treated by the soda lye process under pressure, called in Germany "Strohstoff", has proved its superiority over straw treated in any other manner. It is true it loses half its dry matter viz., the crude protein, and most of the N-free extracts, but the remainder consists essentially of fibre, is easily digested and has the same starch value as pure starch.

The digestibility experiments made with this straw gave the following results.

	Organic matter	N-free extracts	Crude fibre
With cattle according to KELLNER	88.3 %	79.2 %	95.8 %
With sheep » » FINGERLING . . .	73.2	72.2	77.3
With swine » » FINGERLING . . .	88.8	63.7	94.8

"Strohstoff" can be converted into a commercial stock feed by mixing it with molasses ("Strohstoffmelasse", "Strohkraftfutter") according to the OEXMANN method, in which the damp disintegrated straw is mixed with molasses and then dried. By this means, a sticky mass is obtained having the following composition :

Water	9.3 %	9.7 %
Nitrogenous matters	3.6	3.1
Crude fat	0.4	0.4
N-free extracts	29.0	30.8
Crude fibre	53.0	51.4
Mineral substance	4.7	4.6

Starch value 70-75, granting the starch value to be that of pure starch, as has been said.

As disintegrated straw mixed with molasses contains hardly any albumin, it is mixed in Germany with foods rich in albuminoids. First dried yeast was used, and afterwards lupin seeds that had been ground and freed from their bitter taste ; by this means, a commercial feed was obtained which went by the name of "Eiweissstrohkraftfutter". This should contain, at the maximum, 14 % water — 55-60 % of the dry matter of straw of 90 % availability — 22 % of N-free extracts, of which 13 to 15 % is sugar — 10 % crude protein, of which 6 % is digestible albumin — 2 % ash. This feed keeps well.

4.5 lbs. per head and per day can be given to steers, it also suits dairy cows. In the case of horses, 1 lb. : replaces 2.55 lbs. hay and 0.92 lbs. oats ; up to asont 8.8 lbs. per head and per day may be fed, but this maximum must be reached gradually. "Eiweisstrohkraftfutter" can be fed to swine at the rate of $^1/_5$ to $^1/_4$ of their ration, or 3 to 4 lbs. per 1000 lbs. of live-weight.

LEHMANN's method, which has already been mentioned, may also be applied on a small scale on an agricultural farm in order to obtain "Aufgeschlossenes Stroh", or "Kraftstrohfutter". This is prepared either by boiling the straw in an open caldron with caustic soda lye (at least 10 kg. of caustic soda being used per 100 kg. of straw) in order to obtain a feed with the digestibility of bran, or else the straw is boiled with caustic soda lye under a pressure of 5 to 6 atmospheres (using 4 kg. of soda per 100 kg. of straw) which makes its digestibility equal to that of natural meadow hay. If the amount of soda is raised to 10-12 kg. per 100 kg. of straw as digestible a food is obtained as the best concentrates.

The complete plant required for this treatment is supplied by Messrs BROMBERGER (Nollendorfplatz, 6 I, Berlin); it consists of a forage-chopper, a tub for the lye, mixing basin, boiler and washing-tank.

In the COLSMANN process, which is also a home method, the straw is mixed with the soda lye and left standing for 12 hours ; after this it is put into a masonry tank and disintegrated at about 100° C. by means of a current of steam. For each 100 kg. of chopped straw 16 kg. of 33 % soda lye diluted with 267 litres of water are used. After boiling, the mass is carefully washed and pressed ; it then contains 25 to 30 % of dry matter and has the following chemical composition :

	According to REISCH I	According to REISCH II	According to the Köslin Agricultural Station
Water	69.2 %	80.7 %	75.0 %
Crude protein	1.7	1.1	0.3
Crude fat	0.2	0.1	0.3
N-free extracts	2.6	2.3	7.6
Crude fibre	24.8	14.0	16.0
Mineral substances	1.5	1.3	0.8

Large quantitites of war-fodder were made in Germany by the LEHMANN and COLSMANN processes, which made it possible to cope, at all events to some extent, with the dearth of stock-feeds.

A plant for treating straw by the LEHMANN process was installed in L. FAVRESSE's farm at Balâtre, Gembloux (Belgium) in 1917. This agriculturist found the method practical and very useful at the time when there was a scarcity of pulp from the sugar-factories.

When fed to dairy cows, and especially to animals being fattened for the butcher, this straw gave better results at Balâtre than pulp (1).

An excellent method (provided the results obtained are certain) has been proposed by FRANZ LEHMANN for making a stock-feed rich in albuminoids from disintegrated straw and ammonia. The straw was subjected to the action of steam and the ammonia added, after which it was left to heat spontaneously and allowed to cool; subsequently fungi (species not stated) were introduced. At the end of 4 weeks, this straw contained 11.02 % protein, instead of the usual amount, 1.35 %. In another sample of straw treated in the same manner, but with the addition of ammonium sulphate and sodium phosphate, the protein content rose from 3.17 % to 16.41 %.

According to STUTZER, a protein feed could be made from peat by disintegrating it with hydrochloric acid, adding some ammonium sulphate, and inoculating the mass with fungi.

The investigators mentioned in the note at the head of this chapter obtained negative results, as has already been said, on treating straw with acids. STUTZER (2), however, by placing 100 parts of straw for 1 to 2 days in 600 parts water containing 4 parts hydrochloric acid, and subjecting the mixture to the action of steam under a pressure of 3 atmospheres, obtained a greatly improved product, as is shown by the following coefficients of digestibility.

(1) Cf. A. CARLIER. *L'emploi des pailles en alimentation.* Min. de l'Agr., Avis aux Cultiv. Brussels, M. Weissenbruch, 1921, p. 13.
(2) Cf. *Die Landw. Versuchs-Stationen*, Parts 2-3. Berlin, 1915.

	Untreated straw	Treated straw
Organic matter	57.50 %	47.70 %
Crude protein	65.70	—
Fibre	53.00	52.00
N-free extracts	60.20	39.30
Pentosans	83.96	91.75

The straw thus treated is more nutritive; it is brown and has a pleasant smell.

Amongst the methods of disintegration by means of acids should be mentioned SCHWABLE'S process of treating acid with hydrochloric acid, the product *not being subsequently washed.*

HANSEN gives the following figures for straw thus treated: water 23.6 % — crude protein 6.6 % — pure albumin 5.9 % — crude fat 1.9 % — N-free extracts 33.9 % — crude fibre 27.5 %.

This straw is readily eaten by dairy cows and causes no digestive disturbances, but its nutritive value is low: 7 units being only equal to 3 units of natural oat straw or 1 unit of sugar-beet slices. It is much inferior to straw that has been disintegrated by alkalis. A *hydrolised hay flour* is also made in Germany; this contains, according to the analyses carried out at the Bonn Agricultural Station: water 8.9 % — crude protein 2.2 % (pure albumin 1.7 %) — N-free extracts 43.3 % — crude fibre 41 % — mineral substances 3.2 %.

No details of the disintegration process have been published. Feeding tests conducted by RICHARDSEN with cows have proved this feed to be inferior to hay residue, for it only produces, in comparison to the latter, 89.8 % milk and 94 % fat.

OEXMANN (1) has made, in Germany, a compound food with straw flour and straw treated with caustic soda lye. This product he called "Zellulosenfutter". It contained: Straw 65 % — Dried potatoes 20 % — Molasses 15 %. Pigs will not eat it, however, and the results obtained may be regarded as negative.

Straw flour has also been mixed with ground grain and fed with gluten and molasses, or alone as a basal ration (2). The nitrogen not being assimilated, it was concluded that this feed is not profitable.

NOLSSON (3) obtains straw cellulose and sawdust cellulose by reducing the straw and sawdust to a fine paste and adding 10 % of molasses. This feed is also sometimes cut up into slices, but animals will not eat it by itself; horses will only take it mixed with hay or natural straw. Cows and horses will readily eat the cellulose when cut up into little disks and mixed with wheat shorts.

(1) Cf. *Landw. Wochenschrift* für die Provinz Sachsen, year 18, No. 17. Halle, 1916.
(2) Cf. *Mitteilungen der Deutschen Landwirtschafts-Gesellschaft*, No. 16. Berlin, 1915.
(3) NOLSSON J. *Fodercellulosa*. Stockholm, H. Bonniers, Malmö, 1919.

For dairy cows, 1.3 kg. (2.8 lbs.) of cellulose containing 10 % of water makes a nutritive unit, provided albuminoids have been added.

For horses, 1.2 kg. (2.7 lbs.) of the cellulose is equal to 1 nutritive unit.

When cellulose is fed, not less than 40 gm. of digestible protein per nutritive unit may be given, this should be supplied by concentrates. If the forage of the district is poor in mineral substances, lime and phosphates must be added to the ration at the rate of 20 gm. per day per head.

For more detailed information regarding *straw flour* the reader is referred to the chapter bearing this title in the part dealing with *Human Food* (see p. 63).

3. — Maize Rachides and Stems.

When feed is scarce, the rachis (axis or stripped stalk of the maize cob) ground and reduced to flour in special mills can be fed to stock in the form of a paste mixed with hot water and some handfuls of meal. Its nutritive value is however very low, not exceeding that of wheat husks.

The rachis of maize contains: water 9.83 % — crude protein 3.40 % — fat 0.32 % — N-free extracts 49.91 % — crude fibre 34.17 % — fsh 2.37 %.

With the object of making these rachides into an easily digested food SCURTI and MORBELLI (1) have devised a method of treating them by hydrolysis. The product, when finely ground and dried at 100 C., contained: fat 0.52 % — crude protein 1.75 % — fibre 38.6 % — ash 2.11 % — N-free extracts 57.02 % — pentosans 15.81 %. — water-soluble organic matter 5.60 % — organic matter soluble in dilute hydrochloric acid 46.30 %.

The hydrolysis of the maize rachides flour is carried out by subjecting it to the action of 4 % sulphuric acid at a temperature of 130° C. Previously, the flour is mixed with 10 times its weight of water. From 100 units of the flour thus treated, 60 units of cellulose and some 40 units of sacchariferous compounds are obtained.

The *maize stems* are sometimes used as feed in winter, the thinnest and softest being selected. They are passed through a chaff-cutter and fed mixed with hay, straw, bran, or green fodder.

The thicker, harder stems are fermented and put on the manure heap. In the United States, they are used for making a special feed, as a source of cellulose, for making paper, and charcoal, as well as for packing material etc.

The *stalks of Jerusalem artichokes* have on several occasions been employed as a stock-feed, their nutritive value when dried being almost equal to that of meadow hay. If fed alone however, they ferment

(1) Cf. *Le stazioni sperimentali agraric italiane*, Vol. LII, Parts 5-6. Modena, 1919.

in the digestive tracts of the animals, therefore these stems must be used in a mixed ration. Their digestibility has been determined as follows: organic matter 65 % — crude protein 55 % — fat 70 % — fibre 54 % — N-free extracts 72 % — calories 66 (1).

4. — Leaves, Twigs and Young Shoots.

These plant residues have long been employed for feeding livestock. During the war, owing to the scarcity of fodders from artificial meadows, their use was greatly intensified in all the belligerent countries, and in some of them special societies were even created for gathering leaves suitable for stock feeds, as has already been stated in the first part of this Monograph (see p. 32).

The leaves of many trees and shrubs make a good food for cattle, if gathered shortly before the time of their natural fall, and the plants suffer little from the loss of their foliage at that period. In many countries leaves form an efficacious substitute for fresh fodder in summer; the foliage of the olive-tree is frequently used for this purpose, hence it has been well named the "aerial meadow". Amongst the most common trees whose leaves form a good stock-feed may be mentioned the elm, olive, mulberry, poplar, field maple, willow, oak, chestnut etc. (2); turnips, beets, Jerusalem artichokes, cabbages, rhubarb, etc., are herbaceous plants frequently used for the same purpose.

The leaves of many species can be fed just as they are gathered, but some kinds need to be put in the silo.

Elm leaves are very good; they contain about 65 % of water and 5 % albuminoids, of which about half is digestible. The nutritive ratio varies between 1 : 5 and 1 : 5.5 (MENOZZI and NICCOLI).

Willow leaves are most nutritious. According to C. D. HALL (3), they contain when air-dried: water 10.09 % — crude protein 15.3 % — crude fat 5.35 % — crude fibre 19.5 % — carbohydrates 40.4 % — ash 8.94 %. The ash contains: potash 9.93 %, — phosphoric acid 5.04 % — Willow leaves make a good poultry-feed.

DE MARCILLAC (4) succeeded in feeding 25 head of cattle for one winter on *Chestnut leaves*, which had been gathered green together with their twigs from a copse in the height of summer, and kept until December in a cool, dark, well-ventilated room. They were given to the animals either dry, or boiled, after having been chopped.

(1) Cf. *Landw. Jahrbücher*, vol. 46, Part 1. Berlin, 1914.

(2) Cf. 1) P. DECHAMBRE, Technique de l'utilisation alimentaire des feuilles d'arbres, *C. R. Ac. d'Agr.*, Vol. IV, 1918. — 2) DE MARCILLAC, Les feuilles de châtaigner pour le bétail, *C. R. Ac. d'Agr.*, Vol. IV, 1918. — 3) D. CANNON, Sur l'ensilage de ramilles, *C. R. Ac. d'Agr.*, Vol. IV. Paris, 1918. — 4) C. GUYOT, Sur l'emploi des feuilles des arbres forestiers. *C. R. Ac. d'Agr.*, Vol. IV. Paris, 1918.

(3) Cf. *Journal of the Depart. of Agric. South Africa*, Vol. I, No. 5. Pretoria, 1920.

(4) Cf. *Comptes rendus de l'Académie d'Agriculture de France*, Vol. IV, No. 27. Paris, 1918.

As these leaves are heating their action must be corrected by a liberal supply of succulent food such as turnip-tops. The chestnut leaves given with maize silage, kep the stock in excellent condition.

The leaves of the *Nettle-tree* (*Celtis australis*) (fig. 5) make a good fodder for cattle and goats : 100 parts of fresh leaves contain : nitrogenous substances 6.3 — fats 0.15 — carbohydrates 16.69. The fruits, which also make a good feed, have a pulp containing 39.4 % of sugar and a kernel with 67.1 % of fat ; when the latter is extracted, the residue consists of a cake with 12 % protein, 12.4 % fat and 48.5 % of N-free extracts (1).

During the war, an attempt was made, under the direction of A. STUTZER and W. HAUPT (2), to use *Pine-tree needles* (fig. 6) for

FIG. 5. — Nettle tree.
From Dr. A. FIORI, op. cit.

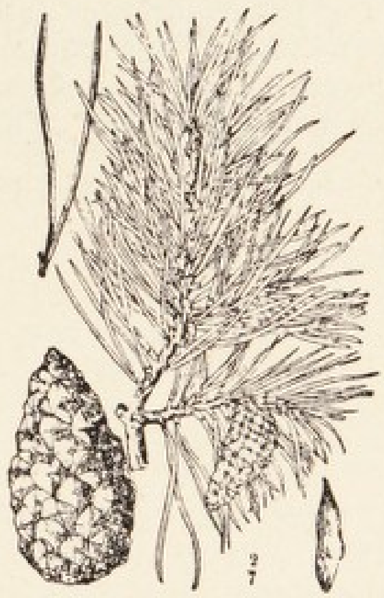


FIG. 6. — Pine tree.
From Dr. A. FIORI, op. cit.

feeding live-stock. They were fed chopped to lambs at the rate of 150 to 250 gm. per head and per day, plus a basic ration, but the animals ate them with reluctance ; 24 % of the organic matter of the leaves was digested when they were mixed with hay or with potato-meal.

The injurious or unpleasant substances can be removed by alcohol and the digestibility thus increased 35 %, but, of course, such treatment is not economical. The digestibility of pine-needles is about half that of hay as regards the fibre and organic matter, but remains well below half in the case of the protein and N-free extracts.

The presence of tannic substances appears to be the chief cause of the unavailability of pine-needles which are unsuitable for a stock-feed.

(1) Cf. DEGLI ATTI M. *Ann. della R. Scuola sup. di Agric. di Portici*, Vol. XIII. Portici, 1916.

(2) Cf. *Landw. Jahrbücher*, Vol. 48, No. 4. Berlin, 1915.

It is, however, possible that a good result might be obtained by an acid treatment as in the case of sawdust (see p. 184).

According to DECHAMBRE (1), 100 lbs. of hay can be replaced by 275 lbs. of the green needles of the *Scotch Pine* (*Pinus sylvestris*).

The *cabbaje* is a very useful herbaceous plant from the point of view of fodder, the outer leaves of the kitchen-garden cabbage, and still more those of the field cabbage, being largely used for feeding stock.

According to I. I. DE VRIERS (2) their alimentary value is comparable to that of cereal residues. The leaves of red cabbages have twice as high a food value as clover hay while the leaves of white cabbages are twice as nutritious as natural meadow hay. Red cabbage leaves however may impart their peculiar smell to milk whereas the leaves of the cauliflower and of the white cabbage have no bad effect upon the fat and the skimming yield.

From 6.5 to about 9 lbs. of these leaves may be given to cows per head and per day. Their percentage composition is as follows:

	Cabbage according to H. C. MÜLLER	Cabbage leaves without veins according to F. MACH
Water	18.8 %	13.6 %
Protein	9.4	15.9
Crude fat	1.3	5.0
N-free extracts	22.0	37.9
Crude fibre	9.7	11.0
Mineral substances	38.8	16.6

Leaves and Root-collars of Sugar Beets. — These can be given either dry or as ensilage (3). According to A. RICHARDSEN'S (4) experiments they suit cows best dry and fed with the basal ration at the rate of 0.8 kg. per day and per 100 kg. of live weight. On the other hand the leaves produce more fat if fed with the basal ration in the proportion of 4 to 6 kg. per day per 100 kg. of live weight. A crop of 20 tons of beets per acre supplies about 10 tons of leaves and root collars.

During the war every effort was naturally made to turn to good account these residues of the sugar beet crop, always available in large quantities. When it was not necessary to utilise them to the full or within a stated time, they were given to the stock green or

(1) Cf. *Comptes rendus de l'Ac. d'Agr.*, Vol. IV, 1918.

(2) Cf. *Nederlandsch Landbouw Weekblad*, Year XXVI, No. 45, 1917.

(3) Cf. J. W. JONES. Beet top Silage and Other By-products of the Sugar-beet. *U. S. Dept. of Agric., Farmers' Bulletin* 1095, Washington, 1919.

(4) Cf. *Landw. Jahrbücher*, Vol. 49, Parts 3-4. Berlin, 1916.

after ensilage, but during the war the plan was adopted in Germany of drying them, not only to preserve them for use, but also for purposes of transport and sale.

The raw material is first chopped and dried mechanically, after which it is passed through a sieve to free it from most of the sand it contains, as this is injurious. Not more than 12 % sand, or 14 % water should be left.

According to KLING this feed contains: water 9 % — crude protein 12 % — crude fat 1 % — N. free extracts 59.6 % — crude fibre 10.5 % — crude ash 7.9 %.

Thus, evidently it should be supplemented by other substances that are richer in albumin. The oxalic acid present makes the feed slightly laxative but its aperient properties are less than those of the fresh leaves. Its digestibility is fairly good: 53.2 % crude protein — 14.8 % crude fat — 83.4 % N. free extracts and 79.4 % crude fibre being available (HONCAMP).

This feed is especially suited to ruminants, if given in a moderate amount, and mixed with a little hay and carbonate of lime. If ground to meal, it may be fed to swine, 4 kg. being used to replace 15 kg. of sharps per head and per day (1).

During the war, dried, ground *stems of seed beets* were put on the market in Germany. According to KLING (2) this feed contains: water 8.8 % — crude protein 5.5 % — crude fat 1.6 % — N. free extracts 49.4 % — crude fibre 24.5 % — crude ash 10.2 %.

These stems were used for making molasses feeds. They were tested by EISENKOLLE on lambs, but proved to be lacking in digestibility. Their starch value is 13.5.

In Germany, a "meal of seed beets stems" was also offered for sale; this was composed of the stems chopped up with a number of leaves and a few ground glomerules, plus 12 % sand, clay and other impurities.

Another similar feed was a mixture of the stems and residues of the seeds of seed beets.

According to KLING (3) it contained: water 10.9 % — crude protein 9.5 % — crude fat 1.9 % — N. free extracts 36.6 % — crude fibre 16.4 % — crude ash 24.7 % (of which 11.9 % is sand).

The leaves and tops of the Sugar cane, instead of being burnt on the field as is generally done, can be made into silage. In this form, they make a nutritious food that is readily eaten by stock, and has an alimentary value little inferior to that of whole maize silage.

Bagasse (the crushed, pressed sugar-canes), provided not more than 50-60 % of their weight has been lost by sugar-extraction, have a certain food value if given fresh, but these stems are more generally piled up into heaps for a year or two, and used as manure (4).

(1) See the figures on page 111.

(2) Cf. KLING, Dr. M., op. cit., p. 53.

(3) Cf. KLING, Dr. M., op. cit., p. 54.

(4) P. A. YODER. Growing Sugar-Cane for Syrup. *U. S. Dep. of Agr. Farmers' Bull.* 1034. Washington, 1919.

Rhubarb leaves had always been used as a manure, but during the war in Germany they were fed to stock, after removal of the large median rib. According to KLING (1) even when dry they are rich in protein (29.9 % being present in the dry matter) but they are best fed green: in that state they contain: water 90.00 % — crude protein 2.80 — crude fat 0.40 — N. free extracts 3.90 — crude fibre 1.00 % — mineral substances 1.9 %.

In some parts of Germany, fields of rhubarb are grown which provide a quantity of leaves.

These can be used as silage, provided they do not make up more than ¼ of the dry matter of the rations, as they are slightly laxative.

The *parings of turnips*, and even slightly damaged turnips make a good stock-feed (2). The dry parings contain: water 9-16 % — crude protein 10-12 % — crude fats 0.92-1.13 % — N. free extracts 41.6 %. Turnips are best dried and sliced, when they contain: water 9-10 % — crude protein 9-10 % — crude fat 1-5 % — N. free extracts 49-58 %.

In 1917, an attempt was made in Germany to (3) obtain a substance suitable for admixture with bread-flours by reducing chopped and dried turnips to a meal which was then mixed with 30 % dried potato flour. The compound however proved quite unsuitable for the purpose and had to be used at a great sacrifice as a stock feed. It contained: water 13.9 % — crude protein 7.5 % — crude fat 1.1 % — N. free extracts 64.1 % — crude fibre 7.9 % — ash 5.5 % — starch value about 65. It is specially suited for a pig feed.

When these parings and damaged turnips are used, care must be taken that they are not really mouldy, and also that there is not more than 1 % of sand, soil etc.

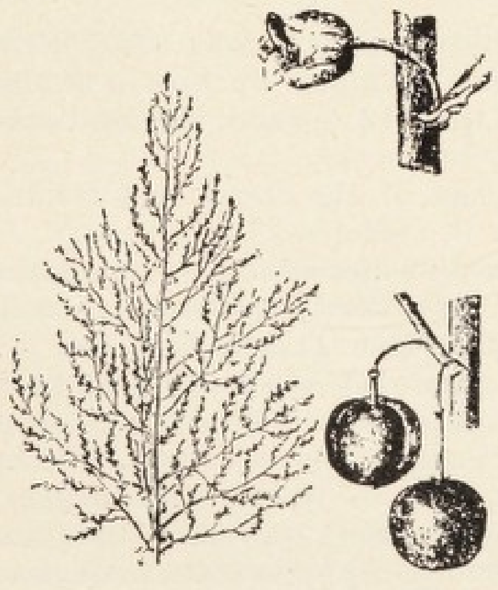


FIG. 7. — Asparagus tops and fruits.

From Dr. A. FIORI, op. cit.

Asparagus tops (fig. 7) when the cycle of growth is complete contain the fruits, and when ground form a residuum that can be used as a forage for cattle and horses, and if not too much lignified also for swine.

According to KLING (op. cit., p. 24) this forage contains: water 7.2 % — crude protein 17.3 % — fat 4.1 % — mineral substances 6.5 %.

In Germany, Prof. RAMANN of Eberswalde suggested using the green or dry twigs (of a diameter not

(1) KLING, Dr. M., op. cit., p. 15.

(2) Cf. *Landw. Jahrbuch für Bayern*, Year VI, Nos. 11-12. Munich, 1916.

(3) KLING, Dr. M., op. cit., p. 70.

exceeding 2 cm.) of all leafy ligneous plants gathered at any time.

These twigs are ground and fermented with about 1 % of ferment (?), in water of a temperature not above 60° C in which some fine bran has been soaked. This food, if some tasty substances be added, is readily eaten by stock.

In countries where *Olives* (fig. 8) are grown, the *pruning residues*, viz. leaves and twigs, are of much importance.

Prof. G. BRIGANTI has made a detailed study of them from which we have obtained the following data (1).

These residues are by no means to be despised ; they contain : water 46 % — total dry matter 54 % — ash 2.9 % — digestible albuminoids 2.9 % — fat 1.2 % — N. free extracts 25 % — nutritive ratio 1 : 9.6 % — commercial units 36.34 (MENOZZI).

FIG. 8. — Olive : branches, flowers and fruits.

From DR. A. FIORI, op. cit.

An analysis made (for this author at the *R. Staz. Agr.* of Modena) of the part of the twigs really eaten by the animals, that is to say omitting the wood, gave the following results : water 31.80 % — total dry matter 68.20 % — ash 5.09 % — digestible albuminoids 5 % — fat 0.75 % — total N-free substances 27 % — nutritive ratio 1 : 5.7 % — commercial units 43.

According to Prof. BRIGANTI, in 2 years, 6 metric tons of branches and leaves of which 2 metric tons can be used for stock are obtained from 2.5 acres planted with 100 olive-trees lopped and pruned alternate years. A large amount of forage can thus be obtained in olive-growing countries, as only the stripped branches should be burnt, but unfortunately great quantities of the leaves are wasted, or used for fuel.

Olive-leaves ought to be fed green as far as possible ; the remainder can be left on the branches : these are piled up in heaps and do not suffer from the sun or bad weather. As soon as the leaves are dry, they are easily stripped off, and are put aside for making the stock feed which is prepared by soaking 40 kg. of the leaves in 100 litres of warm water containing 200 gr. of kitchen salt. They are left to soak for about 12 hours, and then given to the animals which eat them with avidity. Cattle or sheep accept daily 1 to 1.5 kg of green leaves and 0.75-1 kg. of dried leaves per 100 kg. of live weight.

Vine leaves and shoots — These residues of the vine are obtained from the different operations to which the plant is subjected when

(1) Cf. G. BRIGANTI. L'utilizzazione dei cascami dell' olivicoltura nell' alimentazione del bestiame, in *Boll. Soc. Agr. Italiani*, Year XVII, Nos. 16-17. Rome, 1912.

green (topping, removal of leaves and barren shoots, pruning, etc.), the leaves are also collected after the vintage. The quantity obtained naturally varies greatly, but an average of 4 000 kg. of green leaves may be reckoned from one vineyard ; this amount shrinks to 1600 kg. when the leaves are dry. If possible it is better to save labour in picking the leaves by sending the sheep to browse on them on the spot.

The leafy shoots are made into silage and can be used after 40 days treatment. Their food value is equal to that of good hay.

They are prepared as follows (1) ; immediately after the vintage they are all collected, the leaves are stripped off and the shoots are chopped up and crushed thoroughly. The pulp thus obtained is put in the silo, well compressed, and covered with a layer of straw, or beaten earth. When the fermentation is over, that is to say, at the end of 6 to 7 weeks, this feed is ready for eating. It contains a considerable quantity of ethyl alcohol (1.25-1.65 %).

The leaves, which are kept apart, make a better food than the shoots. Their starch value is 42.5.

MOLTZ (2) has suggested grinding the shoots to make a stock feed. According to KELLNER, the one year old shoots contain on an average : water 14 % — crude protein 4.5 % — crude fat 1.4 % — N-free extracts 38.6 % — crude fibre 39.3 % — ash 2.2 % — starch value 14.3.

The fibre should be removed by machine, after which the shoots can be fed to horses at the rate of 2 kg. a day, and to cows at the rate of 4 kg. Vine shoots are, however, of less value than oat straw (CZADEK), and can only be used in case of necessity as a substitute for roughage. As was said above, they are more digestible and acceptable to cattle when made into silage.

Heather meal (3) — The species used is (*Calluna vulgaris* Willd. = *Erica vulgaris* L.) (fig. 9.) the ling, a low shrub, with erect branches and terminal clusters of pink, or white, flowers.

Before the War, this plant was at most tied up in bundles for firewood, or used like the other varieties of heath as a support for silkworm cocoons, but during the war lack of forage obliged many agriculturists, especially in Germany, to have recourse to it for feeding their stock. From the very beginning of hostilities, ling was fed to the cows, first in its natural condition, and then dried and mixed with the Cross-leaved Heath (*Erica tetralix*), the more lignified stalks being dried and made into two kinds of fodder-meal, known as " Heidemehl I " and " Heidemehl II ".

The first was prepared as described above, while the second was made by grinding the stalks separately ; and was used for making molasses feeds.

From 100 parts of fresh *Erica* about 30 parts of No. 1 meal are obtained.

(1) Cf. VENTRE, in *C. R. de l'Académie d'Agriculture de France*, Vol. V, No. 9. Paris, 1919.

(2) Cf. KLING, Dr. M., op. cit., p. 66.

(3) Cf. KLING, Dr. M., op. cit., pp. 22-24.

KLING gives 6 different analyses of "Heidemehl I" made by himself and other chemists : the averages of these is : water 9.63 % — crude protein 5.95 % — crude fat 5.98 % — N-free extracts 44.66 % — crude fibre 26.8 % — crude ash 6.96 %.

The animals refuse these meals at first, but afterwards become accustomed to them, and soon show evidence of their nutritive qualities. These "Heidemehle" can be given to cattle, horses, sheep and goats. They should be fed soaked to ruminants, but only slightly moistened when used for horses. To young pigs small quantities of Meal I can be given mixed into a paste. Meal II has little nutritive value, and chiefly serves as an excipient. Its feeding qualities and appetising character can however be improved by admixture with other substances as is the case also with the common broom.

FIG. 9. — Heather.

From FRANCÉ, R. H. Floristische Lebensbilder. Stuttgard, Kosmos Gesell. der Naturnfr., 1908.

The Common Broom (*Sarothamnus scoparius*) (1). — Of this plant only the upper, more tender, portions can be fed to horses and cows. According to F. MACH, they contain when green : water 57.4 % — crude protein 6.1 % (of which 4.6 % is digestible) — crude fat 0.9 % — N-free extracts 22.8 % — crude fibre 11.6 % — crude ash 1.2 %.

Prof. R. GOUIN (2) states that this forage should be ground, mixed with cereal chaff, moistened with salt water, or molasses, and allowed to ferment for 12-24 hours before use. Before being fed, some concentrated feed must be added such as oil-cake, milling offal, grain screenings, etc. Care must be taken not to give too much broom to stock as 1 kg. of this plant contains about 3 gm. of spartein, a poison affecting the action of the heart.

(1) Cf. KLING, Dr. M., op. cit., p. 33.
(2) R. GOUIN. *Les aliments du bétail*. J.-B. Baillière et Fils, Paris, 1922, p. 73.

Young beeches (1). — These often cover the soil of beech woods and are regarded as valueless, since they will never grow into trees. They are easily uprooted and were therefore recommended as a feed for swine, horses and and cattle in Germany during the war. It is, however, more economical to turn out the pigs to graze on them *in situ*.

They have generally been used green, but can also be dried. The percentage composition of these young plants when green and dry is respectively: water 81.1 — crude protein 5.7-30 — crude fat 0.6-3.2 — N-free extracts 8.4 (of which 0.16 % is tannic acid)-44.7

FIG. 10. — Willow (*Salix alba*): branch and flovers.

From Dr. A. FIORI, op. cit.

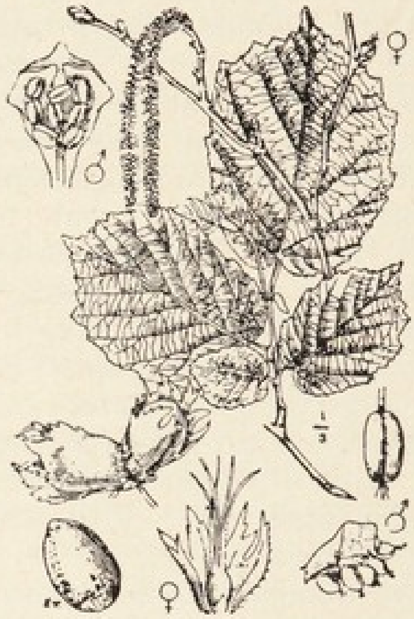


FIG. 11. — Haze *Corylus Avellana*): branch, flowers and fruits.

From Dr. A. FIORI op. cit.

(of which 0.85 % is tannic acid) — crude fibre 2.8-14.6 — crude ash 1.4-7.5.

Female inflorescences of willow (2) (fig. 10). — Before the war these were very seldom used; during the war, however, they were employed in Germany as a stockfeed, and proved the first year to be an excellent green forage, especially for young animals.

According to MACH, these inflorescences contain: water 72 % — crude protein 5.3 % — crude fat 0.7 % — N-free extracts 16.1 % — crude fibre 3.9 % — crude ash 2 %.

Hazel catkins (3) (fig. 11). — These have been used dried and ground as a substitute for wheat bran.

Sumac leaves — It is well known that the leaves of *Rhus coriaria* L. (fig. 12) are rich in tannin (13-16.5 %) and used in tanneries. This

(1) Cf. KLING, Dr. M., op. cit., p. 33.
(2) Cf. KLING, Dr. M., op. cit., p. 32.
(3) KLING, Dr. M., op. cit., p. 33.

tree is a native of the dry and in particular the hot regions of South Europe and temperate West Asia. In Sicily it is fairly extensively grown. Needless to say, the leaves whether fresh or dry are, unless previously treated, totally unfit for a stock feed and indeed no animals will touch them. During the war (1), however, these leaves after being freed from tannin by soaking in water and dried were put on the market in Germany. According to two analyses made respectively by HASELHOFF and A. SCHOLL, they contained: water 10.1-6.7 % — crude protein 9.7-10 % — crude fat 8.2-6.7 % — N-free extracts 40.0-45.5 % — crude fibre 19.3-21.8 % — crude ash 12.7-9.3 %.

In composition, these residues resemble oak leaves. As their effect upon animals is unknown, they must be fed with caution.

The following table gives the average percentage of the dried leaves of various plants that can be used as a stock feed. The figures have been taken from E. POTT (op. cit., vol. II, p. 308 et sqq.) who has obtained them from the data supplied by several authors.

FIG. 12. — Sumac: branch, flowers and fruits.

From Dr. A. FIORI, op. cit.

FIG. 13. — Ash (*Fraxinus excelsior*): branch, flowers and fruits.

From BRUTTINI A., Diz. di Agric. Milano, F. Vallardi, 1901.

(1) Cf. KLING, Dr. M., op. cit., p. 17.

Percentage Composition of the dried leaves of various plants.

Species	Dry matter	Nitrogenous matter	Crude fat	N-free extracts	Crude fibre	Ash
Alder	—	19.8	5.0	48.5	10.3	4.4
Lime	—	16.2	2.9	44.3	13.2	11.4
Elm	—	15.9	2.9	49.9	8.6	10.7
Horse-Chestnut	—	14.7	2.0	48.5	14.9	7.8
Hazel	—	13.8	3.1	54.4	10.0	6.7
Poplar	—	13.4	4.1	50.5	11.2	8.8
Nettle-tree	—	12.3	4.8	44.7	10.5	15.7
Ash (fig. 13)	—	10.1	2.3	59.0	8.9	7.7
Plane	—	9.8	1.4	47.7	17.6	11.4
Hornbeam (fig. 14)	—	8.7	2.9	56.0	15.4	5.1
Service tree	—	7.5	4.6	56.9	11.0	8.1
Beech	84.6	5.6	3.1	47.0	25.2	3.8
Birch	84.3	4.3	10.6	42.7	24.5	2.2
Oak	85.2	14.8	3.8	41.9	20.6	4.1
Willow	82.8	13.5	3.6	41.1	17.1	7.6
Robinia pseudacacia	85.3	15.2	2.3	36.3	24.7	6.9
Common maple	85.1	10.2	5.4	42.6	18.3	8.6
Mulberry	88.0	16.3	4.1	49.6	6.9	11.0
Spanish Chestnut (fresh leaves)	54.0	4.3	4.4	32.9	10.0	2.4
Mistletoe (with berries)	89.3	15.3	8.9	20.3	26.7	8.7
Fir (green needles)	42.4	3.3	4.1	22.2	11.2	1.6
Spruce (dry needles)	88.0	6.4	6.3	46.0	26.6	2.7
Heather (fresh tips)	43.9	3.5	4.2	17.4	15.6	3.2
Heather (dried tips)	92.7	5.2	5.2	44.6	34.3	3.4
Male fern (silaged)	34.0	4.4	0.7	11.2	15.3	2.4
Algae:						
Fucus vesiculosus	76.2	5.3	4.3	47.5	2.9	16.2
Fucus serratus	94.2	15.5	1.1	46.2	3.9	27.6
Laminaria esculenta	71.7	9.1	0.4	34.2	6.3	21.1
Zostera marina	87.5	13.3	2.2	39.3	17.6	15.0
Lichens:						
Cetraria islandica	87.2	3.2	3.3	74.5	4.9	1.3
Cladonia rangiferina	90.0	3.2	1.7	62.1	19.5	3.4
Usnea barbata	86.7	7.2	3.1	48.7	16.9	10.9
Lecanora esculenta	93.0	1.9	1.0	18.1	32.0	28.0

In order to obtain figures giving an approximate idea of the world's production of sugar-beet residues (in this case the leaves and root-collars) the basis taken is the average leaf and collar production per 100 kg. of roots, although it must be admitted that this is very variable, ranging between 33 kg. and more than double per 100 kg. of roots. Our estimate therefore can only be approximate, since it must be based on the total average production of the sugar-beet, but it will give some idea of the large quantity of nutritive substances supplied by the residues of the beet crop. By taking the average between the extreme figures of MUNERATI (33 kg.) and of SCHNEIDEWIND (66 kg.) we obtain 49.5 kg., or in round numbers, 50 kg. of leaves and collars per 100 kg. of roots.

In order to estimate the amount of digestible nutritive substances and of fertilising principles, we have borrowed from MUNERATI (1) the following average percentages for the leaves and root-collars taken together: protein substances 2 — n-free extracts 7.3 — fat 0.2 — nitrogen 0.3 — phosphoric acid 0.1 — potash 0.37.

From these figures, the statistical data obtained from a world production of roots amounting to 47,459,510.2 metric tons (2), the average for 1909-10 to 1918-19, would be as follows:

FIG. 14. — Hornbeam. (*Carpinus betulus*).

From BRUTTINI A. op. cit.

Amount of nutritive and fertilising elements contained by the leaves and collars of the world production of sugarbeets for the period 1909-1910 *to* 1918-1919 (*taking the total as* 47,459,510.2 *metric tons*).

As forage:

Albuminoid substances. . . .	(2 %)	949,190.2 m. tons
N-free extracts	(7.3 %)	3.464,544.2 m. tons
Fat	(0.2 %)	94,919 m. tons

As manure:

Nitrogen	(0.3 %)	142,378.5 m. tons
Phosphoric acid.	(0.1 %)	47,459.5 m. tons
Potash.	(0.37 %)	175,600.2 m. tons

(1) Cf. MUNERATI, O. *La Barbabietola*, p. 100. Turin, Unione Tip. Ed. Torinese, 1911.

(2) Cf. INTERNATIONAL INSTITUTE OF AGRICULTURE, *International Yearbook of Agricultural Statistics*, 1917-1918. Rome 1920, p. 89.

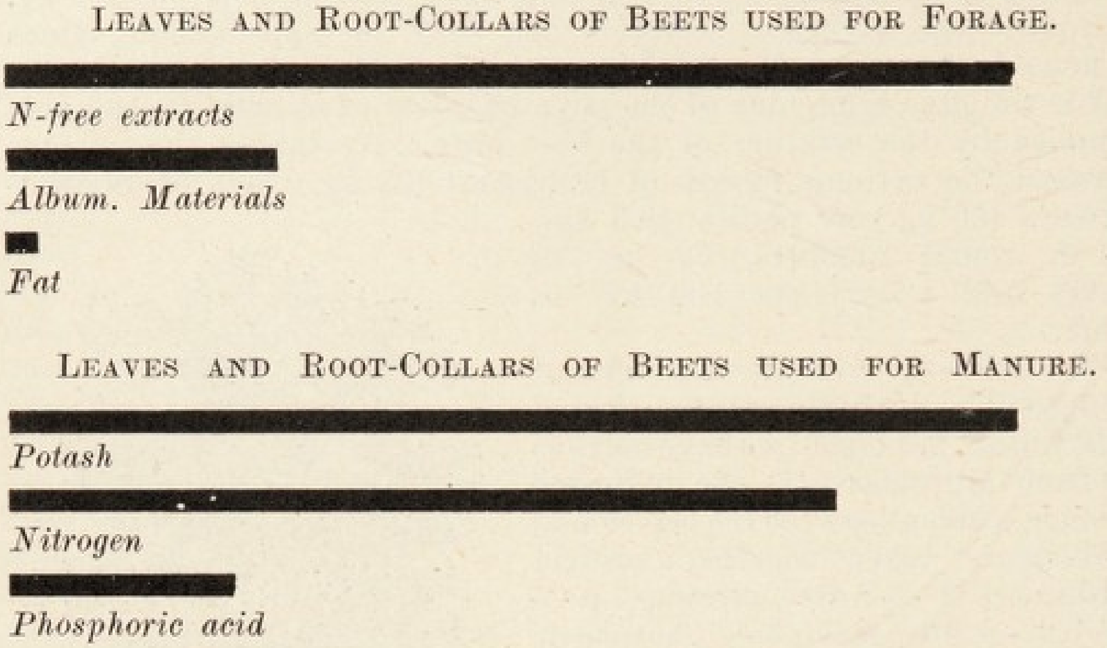


Fig. 15. — Diagram showing the world average annual production of leaves and collars of Sugar-beet.

5. — Prickly Pear Slabs (1).

These are not a residue properly so-called, but a plant product very plentiful in certain countries and obtained especially from species of wild *Opuntia*, which do not bear good fruit like the Prickly Pear (*Opuntia ficus indica*) (fig. 16) widely cultivated for its fruit in Sicily, Asia Minor, America etc. (The slabs of this too have been used from time immemorial as a feed for cattle, sheep and goats, and are in this sense a residue turned to stock-raising purposes).

In a series of experiments made in South Texas under the direction of the Bureau of Animal Industry of the Department of Agriculture of the United States use was made for 3 years of the slabs of *Opuntia gommei, O. cyanella,* etc. Their average composition was: water 91.30 % crude protein 0.58 % — albuminoid protein 0.29 % — ether

(1) Cf.: 1) *Journal of Agricultural Research*, Vol. IV, No. 5, Washington, 1915. — 2) *Institute of Science and Industry, Bulletin* No. 12, Melbourne, 1919. — 3) *Queensland Agricultural Journal*, Vol. VI, Part. IV, 1916. — 4) *Department of Agriculture, Bombay, Bulletin* 58, Bombay, 1914. — 5) *New Mexico Coll. of Agr. and Mechan. Arts, Agr. Exp. Stat., Bull.* No. 64. Albuquerque, 1907. — 6) D. Griffiths. *U. S. Dep. of Agr., Bureau of Plant Ind., Bull.* No. 124. Washington, 1908; *Farmer's Bulletin* No. 483, Washington 1912, and No. 1072, Washington, 1920. — 7) S. Biuso. Il Fico d'India in Sicilia, Palermo, 1879. — 8) Dr. G. Guastella. Coltiv. del Fico d'India, Catania, Battiato, 1913. — 9) Juritz Ch. F., Prickly Pear as a Fodder for Stock. *Dept. of Agr. Union of South Africa, Sc. Bull.* No. 16, Pretoria, 1920. — 10) N. V. Hanmante. Exp. of Prickly Pear as an Emergency Cattle-Food. *The Agr. Journ. of India*, Vol. XVII, Part. IV, Calcutta, 1922. — 11) L'emploi du Cactus pour l'alim. des anim. *Suppl. au No. 3 du Bull. de l'Off. du Gouv. gén. de l'Algérie.* Paris, 1910. — A. Stead and E. N. S. Warren. Prickly Pear, its value as a fodder for sheep. *Union of South Africa. Dept. of Agr.* Bull. No. 4. Pretoria, 1922.

extract 0.12 % — N-free extracts 4.67 % — crude fibre 1.16 % — ash 1.76 %.

The best rations for dairy cows (per head and per day) were as follows: sorghum hay 1.5-2.7 kg. + prickly-pear slabs 27-45 kg. + ground cotton-seed cake 0.5 kg., or else: prickly pear slabs 50 kg. + ground cotton-seed cake 0.9 kg.

When fed alone these slabs do not give satisfactory results, for though they have no bad effect upon the milk, they slightly reduce its fat content. They should not be given in larger quantities than 27-34 kg. per head per day for fear of producing diarrhœa or even a reduction in live weight. Feeding experiments made on sheep at the Grootfontein Agricultural College in South Africa (1) have shown that sheep fed on 12 lb. per head of these slabs for more than 250 days require no drinking-water. This feed was, however, supplemented with substances richer in protein, for instance, lucerne hay.

Fig. 16. — Prickly-Pear.
From Francé, op. cit.

Opuntiae thus save drinking-water which renders them invaluable in times of drought. In an experiment made with cattle in Queensland (Australia) slabs of *Opuntia inermis* (aspineless variety) that had not been scorched or singed, were fed and no water given for 4 months, but from 18.2 to 20.5 litres of liquid a day were obtained by the animals from these succulent stems. The best complementary feed was a small quantity of lucerne hay and oil-cake.

Opuntia inermis must never be given alone, as it decreases the fat content of the milk, although it may slightly increase the milk yield. It is not suited to nursing-ewes, or to lambs.

In British India, Horn used chopped spiny slabs from which the spines had been removed by singeing. They were fed for 6 months to steers in the proportion of 100 parts slabs to 6 parts of cottonseed, and at the rate of 7.2 kg. per head and per day. The animals throve on this ration, as did also some dairy cows and buffaloes that were given 6.3 kg. of the same mixture.

(1) Cf. *The Agr. Gaz. of New South Wales*, Vol. XXXIV, Part. 1, Jan. 1923. Sydney.

The residues of the edible Prickly Pear fruit are the skins which can be fed fresh, especially to pigs.

The quantity of skins and seeds constitute a considerable percentage of the fruit especially in Mexico, the original home of this cactus, where the residue amounts on an average to 56.18 %. Both the slabs and skins are fed fresh, as they can neither be dried nor made into silage. In Italy, and other South European countries, and in North Africa, where the prickly pear grows well, its stems can be used as a supplementary, or emergency, stock feed, especially in summer, although they must not be given exclusively or in the form of a basal ration. Care should be taken only to use slabs 2 or 3 years old, as when younger they cause diarrhoea, and the older stems become too tough. The spines must be burnt off and the slabs cut into slices before they are fed.

L. BURBANK's (1) important work on *Opuntia* is well-known. This celebrated plant-breeder has succeeded in creating a spineless cactus with a view to its use as a forage plant in arid regions, but as it is not a wild plant it does not come within the scope of this work, and is therefore merely mentioned here.

6. — Marsh and Water Plants (2).

These are generally regarded as useless, or at best are employed as litter (3).

One of the marsh plants most suited for forage is the Reed-grass (*Phalaris arundinacea L.*) (fig. 17) which gives two or if manured, three crops a year. It attains the height of 1.80 m. The Reed-grass must be cut before flowering, otherwise it becomes too hard.

(1) LUTHER BURBANK, His Methods and Discoveries and Their Practical Application, Vol. VIII, Burbank Press. New York and London, 1914.

(2) Cf. : 1) HEYKING in *Georgine*, Year 8, Nos. 35-36. Königsberg, 1915. — 2) ERTZDORFF and KUPFER in *Landw. Jahrbücher*, Vol. 48, No. 3, Berlin, 1915. — 3) FLÜGGE, W. *Beiträge zur Kriegswirtschaft*, Parts 34-38, Die Fische in der Kriegswirtschaft. Berlin, 1918. — 4) PARANJPIE, H. P. in *The Agricultural Journal of India*, Vol. XV, Part III. Calcutta, 1920. — 5) HOERING has devised a method of making briquettes for fuel from marsh plants cut into pieces of 1-3 cm. dried till they only contain 8 % of water and pressed. The heating power of this material was 4000 cal. and it can also be used in steam-engines. (Cf. KOLLER, Dr. TH., op. cit., p. 38).

(3) As an important instance may be mentioned *falasco*, a mixture of marsh plants much used as litter in the country districts of Pisa and Emilia. According to Prof. F. SESTINI, it is chiefly composed of the following species : *Phragmites communis* — *Scirpus maritimum*, *S. triqueter* — *Sparganium ramosus* — *Cyperus longus*, *C. Monti* — *Carex paludosa* etc. — *Glyceria aquatica* — *Juncus anceps*, *J. Terageya*, etc. — *Sagittaria sagittifolia* — *Catabrosa aquatica* — *Typha latifolia*, *T. angustifolia*, etc.

According to the same author, the average percentage composition of *falasco* is as follows: water 14.94 — fat 2.72 — fibre 23.52 — protein substances 4.77 — carbohydrates and non-protein substances (per diff.) 49.37 — mineral substances 4.68. In 100 kg. there are : total nitrogen 0.893 — phosphoric anhydride 0.279 — potash 0.856, sodium chloride 1.344, secondary constituents 85.

This marsh product can thus well be used for stock-feeding and as a litter, otherwise it accumulates and forms peat (Cf. A. BRUTTINI. *Dizionario d'Agricoltura*, Vol. I, F. Vallardi, Milan, 1901, p. 308).

The Common reed (*Phragmites communis*) (fig. 18) can be cut two or three times in the year. It is chiefly fed to horses either chopped green and mixed with straw, or else dried. Like the Reed-grass, *Phragmites communis* is fairly rich in nutritive principles.

Before the war, it was used in Germany only as litter, or for thatching roofs, but during the war, it served not merely as a forage for cattle and horses — as has been said — but as a substitute for coffee and a source of saccharose.

If the reeds are cut before they flower, cows and sheep eat them readily, but once they have become lignified, their forage value is

FIG. 17. — Reed-grass

From Dr. A. FIORI, op. cit.

FIG. 18. — Common reed.

From Dr. A. FIORI, op. cit.

lost. The upper part of the reed which bears most leaves is more valuable than the lower portion, and young plants are the most useful.

Young air-dried reeds contain: water 6.8 % — crude protein 29.1 % — ash 12.4 % — digestible albumin 10.7 %. In his experiments on lambs, M. HONCAMP obtained the following coefficients of digestibility which are by no means high: organic matter 33.3 % — crude protein 36.5 % — crude fat 35.1 % — N. free extracts 26.6 % — crude fibre 40.6 %.

During the war, the " Kriegsausschuss für Ersatzfutter " (War Commission for Forage Substitutes) had a food prepared which was called " Schilfrohrmehl " (Reed flour); it was made from well-developed plants and contained 5-9 % protein and 30-59 % crude fibre, its nutritive value being about the same as that of straw-meal.

Reeds make very good food for cattle and horses; they need not be ground when fed to the latter. The flour mixed with the tips of very young reeds is the best form in which to feed them to pigs.

Floating *Poa* (*Glyceria fluitans*) (fig. 19) grows in stagnant or slow-running waters. Like the other species, *G. aquatica* and *G. spectabilis*, it is eaten with avidity by stock.

The following are two analyses of the whole plant of *Glyceria aquatica*: crude protein 11.2-10.6 % — pure albumin 9.7-9.2 % — digestible albumin 7.0-6.6 % — fat 2.5-2.6 % — N. free extracts 37.7-41.2 % — sugar 7.7-9.4 % — crude fibre 27.5-26.9 % — mineral substances 9.1-6.7 %.

The following plants were also used during the war as a stock-feed especially in Germany, where they were given green or boiled

FIG. 19. — *Glyceria fluitans.*

From Dr. A. FIORI, op. cit.

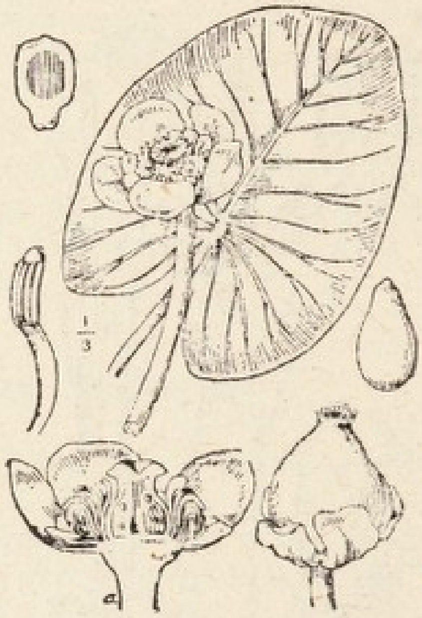


FIG. 20. — Yellow water-lily.

From Dr. A. FIORI, op. cit.

to swine and poultry: *Nuphar* (yellow water-lily) (fig. 20), *Nymphaea* (white water-lily) (fig. 21), Duckweeds, and Watercress and Pondweed, also *Salvinia natans* (fig. 22) Hoff.

Duckweed (1). This name is given to the *Lemnaceae*, a family including several genera (*Lemna arrhiza*, *L. gibba* (fig. 23), *L. monorrhiza*, *L. polyrrhiza* and *L. trisulca*), all common plants growing in ditches or ponds. They form a food with a high water content, but the solid portion is rich in nutritive substances.

A. MAYER states that the composition of *L. trisulca* when fresh is as follows: dry matter 5.7 % — nitrogenous substances 1.8 % — crude fat 0.2 % — N. free extracts 2 % — crude fibre 0.6 % — ash 1.1 %. It is a good food for swine and poultry. It can be preserved by putting it into the silo, or else by drying it first in the air and afterwards in the oven, or drier. When dry, it suits fowls excellently; its

(1) Cf. 1) KLING, Dr. M., op. cit., p. 30. — 2) POTT, E., op. cit., Vol. II, p. 348.

FIG. 21. — White water-lily.
From Dr. A. FIORI, op. cit.

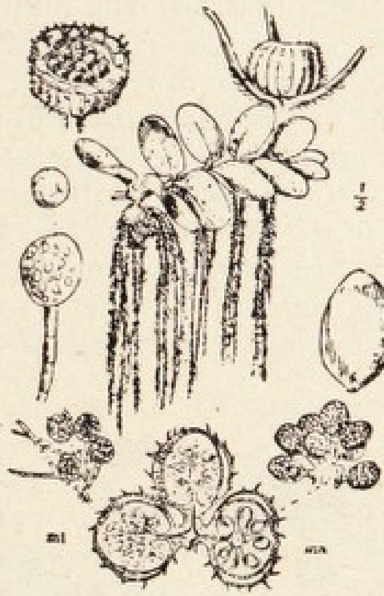


FIG. 22. — *Salvinia natans.*
From Dr. A. FIORI, op. cit.

percentage composition is: crude protein 30.4 — crude fat 2.7 % — N. free extracts 24 — crude fibre 20.8 — ash 22.1

Owing to the great dearth of forage in Germany during the war, an attempt was made to use also rushes (*Juncus effusus* L. and *Scirpus lacuster* L.) (fig. 24) for feeding stock.

Rabbits will readily eat the former if it is very dry. It proved digestible when fed dry to dairy cows, at the rate of 6 kg. per head and per day, but even 2 kg. a day decreased their milk yield. *Scirpus* too affects the quantity though not the quality of the milk.

HONCAMP and BLANCK found the dry matter of *Scirpus maritimus* (cf. KLING, op. cit., p. 29) contained: crude protein 10.3 % — pure albumin 0.2 % — crude fat 2.2 % — N. free extracts 46 % — crude cellulose 31 % — ash 10.5 %.

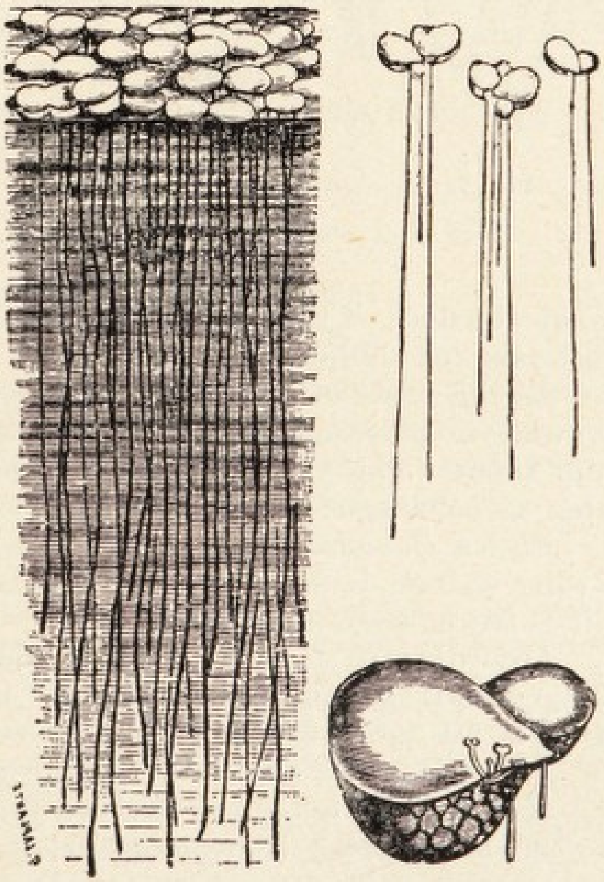


FIG. 23. — *Lemna gibba.*
From FRANCÉ, op. cit.

In experiments on lambs

HONCAMP obtained the following coefficients of digestibility: organic matter 43.3 % — crude protein 42.6 % — fat 52 % — N. free extracts 37.6 % — crude fibre 51.7 %. This forage has a food value comparable to that of good summer stubble.

Typha sp. (Reed maces). It is well known that these common plants of the marshes, ditches etc. of which the chief species are *Typha latifolia* (Great Reed mace) (fig. 25) and *T. angustifolia* (Lesser Reed mace) are used for making mats, cord, baskets, roofs of huts etc. During the war, a society was formed in Germany under the name of the " Typha Verwertungs Gesellschaft " for the extraction and working

FIG. 24. — *Scirpus lacuster.*

From Dr. A. FIORI, op. cit.

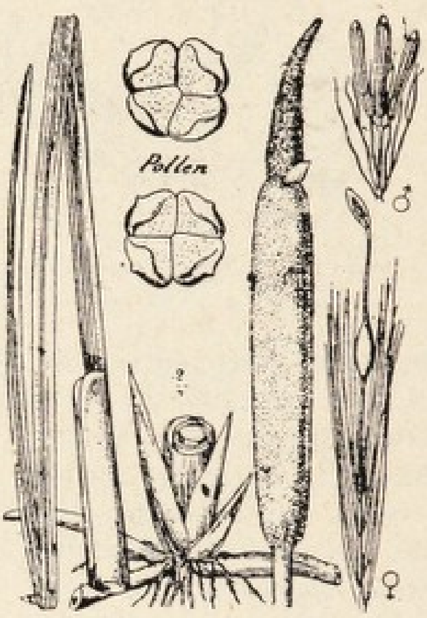


FIG. 25. — *Typha latifolia.*

From Dr. A. FIORI op. cit.

up of the fibre of the reed mace. The latter was used also for making materials for soldiers' cloaks.

As the roots of the plants are very rich in starch, they were fed to swine in place of potatoes, and a kind of flour was also extracted from them. The young shoots of the reed mace can be cooked and eaten as asparagus which they much resemble as regards flavour.

Elodea Canadensis (1). — A plant growing in still, or very gently-flowing waters. It is a native of Canada. Cattle and pigs eat it readily, if it is fed as soon as gathered.

According to HOFFMEISTER it contains when fresh: dry matter 12 % — nitrogenous matter 2.2 % — crude fat 0.3 % — N. free extracts 5.1 % — crude fibre 2 % — ash 2.4 %.

Elodea can be preserved in the silo.

Mosses, Liverworts and Lichens (2). — The mosses here in question are the Bog-mosses (*Spagnaceae*) that live in wet and marshy places.

(1) Cf. POTT, E., op. cit., Vol. II, p. 347.
(2) POTT E., op. cit., Vol. II, p. 350.

When moistened after being dried, they absorb a large amount of water. They have been used, especially during the war, as a substitute for straw in feeding horses and cows. According to TREFFNER these mosses, if air-dried, contain : water 12.6 to 15.6 % — fat 0.5 to 2.2 % — sugar 10.42 %.

Analyses made at the " Königliche Landw. Zentral Versuchs-Station " of Munich gave the following figures : water 10.6 % — crude protein 11.7 % — crude fat (resins) 5.2 % — N. free extracts 32.1 % — crude fibre 35.1 % — ash 5.3 %.

As regards their composition, these mosses may be compared to good hay made from leguminosae (Cf. KLING, op. cit., p. 36).

Mosses and liverworts, should be boiled or steamed before they are fed to stock.

Several species of lichen (*Cetraria islandica*, *C. nivalis*, *Cladonia rangifera*, *Usnea barbata*, *Lecanora esculenta* etc.) are eaten by wild ruminants (reindeer etc) and also by domestic animals of the same group.

Brackish water plants, for example, herbs and shrubs growing over immense tracts on the banks and at the mouths of the rivers on the West coast of India, have also been used for forage. Some of the chief species are *Acanthus ilicifolius*, *Avicennia officinalis* and *Aleuropus villosus*. They given chopped to cattle either alone, or mixed with other fodders. Certain species of *Fucus* have also been employed as a stock feed, especially *F. vesiculosus* of which the percentage composition fresh and dry respectively is : water, 37.97-11.82 — crude protein 6.50-10.52 — fat 1.65-3.43 — N.-free extracts 26.78-41.93 — crude fibre 8.95-20.00 — ash 14.13-16.32.

This *Fucus* can be fed, dried and ground, to cattle, swine and poultry, but only as a supplementary ration.

7. — Seaweed and Iceland Moss.

It is well known that in certain maritime countries (Japan (1), Ireland, Scotland, the Fåroe, Norway, etc.) certain kinds of algae have long and habitually formed an article of human diet, but such use has no special connection with the subject under discussion here.

(1) In Japan, a very important product called *Kanten* is obtained from algae. This is a kind of glue prepared by heating, cleansing, washing and bleaching the seaweed in the sun, after which it is boiled in fresh water and the resulting viscous substance is strained through a coarse cloth and dried in a wooden box. On becoming gelatinous this extract is compressed in a box with a wire bottom and issues in the form of threads which are dried in the air and despatched to the market. This substance is used as a substitute for fish glue, and in China is employed in making artificial edible birds-nests.

Another less refined seaweed glue is known as *Funori*. The algae are washed, dried in the sun and rolled. The glue is used to mix with colour-washes and in the treatment of paper etc.

« *Kombu* » is a generic term applied to edible seaweeds; from it a large number of foodstuffs are prepared. These algae come almost entirely from Hokkaido where they are gathered from the rocks.

It is however a matter of less general knowledge that seaweed has been fed to horses since remote antiquity, and that during the world war it was again successfully tried and recommended as a means of supplementing the shortage of feeding stuffs.

The army-horses of JULIUS CAESAR'S troops were fed on seaweed in Tunisia, during the African campaign, to save them from starvation. It is not known what species were used for the purpose, but judging from the great seaweed banks now found on the shores of North Africa, and especially on those of Tripolitania, it would seem that the plant given to the horses was not properly speaking an alga, but rather a *Naiadacea*, *Posidonia oceanica* (see fig. 27 and p. 218) though very possibly there was a certain admixture of true seaweeds such as *Laminaria*, *Fucus* spp. etc. (1).

The Laplanders feed seaweed to their cattle and the inhabitants of the coast of Ireland and Scotland, and those of the Fåroe give it to their horses as well.

As regards modern experiments with forage seaweed, we may mention two studies made in France by ADRIAN and LAPIQUE respectively (2).

The seaweed used in these researches (*Laminaria flexicaulis*) was thoroughly washed with fresh water with the addition of a little lime (4-5 gm. per litre) and a small amount of acid to prevent the formation of mucilage, then rinsed for 15 minutes and subsequently dried in the air. Through this treatment the seaweed loses its hygroscopicity and much of its salts content, and is then known as crude algine. This keeps as well as hay and retains 40 % of its sugar whereas the repeated washings, originally part of the process, reduced the sugar to 3 %.

Laminaria flexicaulis, when dried, had the following percentage composition: water 14.40 — carbohydrates 52.60 — nitrogenous substances 17.30 — fibre 11.59 — mineral substances 3.90 %. This is almost the same as the composition of oats; in fact ADRIAN estimates that 750 gm. of the seaweed are equivalent to 1 kg. of oats.

The horses used in the experiment soon became accustomed to this forage and digested it very well, as much as 100 % being probably available. In the case of horses that are not being worked, LAPICQUE believes that the whole oat ration might be replaced by the

(1) The following is the passage from Julius Caesar's History of the War in Africa in which mention is made of algae being used as food for the horses: "... Caesariani "gravi annona sunt conflictati, pabulique inopia premebantur. Qua necessitate coacti ve- "terani milites equitesque, qui multa terra marique bella confecissent et periculis inopiaque "tali saepe essent conflictati, alga e littore collecta, et acqua dulci eluta, et ita jumentis "esaurientibus data, vitam eorum producebant" (Biblioteca degli Scrittori Latini, *De Bello Africano*, c. XXIV, p. 720. — Antonelli, Venice, 1836).

(2) ADRIAN in *Comptes rendus de l'Académie des Sciences*, Vol. 166, No. 1. Paris, 1918. — LAPIQUE, *Ibidem*, Vol. 167, No. 27. Paris, 1918. — Cf. also: 1) J. COSTANTIN and F. FAIDEAU. Les Plantes. Larousse, Paris, 1922, p. 280. — 2) SAUVAGEAU, C., Utilisation des Algues marines. O. Doin, Paris, 1920. — 3) TORANDE, L. G. Bernard Courtois et la Découverte de l'iode. Vigot Fr. Paris, 1921, p. 51. — 4) P. LINDNER. Zur Auswertung der Meeresalgon, in *Zeitschr. für techn. Biologie*. Vol. X. Lepzig. 1922, p. 193.

alga. It has a rather higher mineral content than oats and also contains a little iodine, but no bad effects were observed on feeding it at the rate of 2-2.5 kg. per head and per day. The same cannot be said in the case of *Fucus serratus*. The seaweeds most common in the European seas after *Laminaria flexicaulis* are *L. saccharina*, *L. Cloustoni* and *Saccorriza bulbosa*.

Other investigations on this subject were made, during and after the war, by BROCQ-ROUSSEAU, Head of the French Veterinary Service (1). In his experiments on Hungarian draught-horses it was proved that their oats ration could be entirely replaced by seaweed without at all affecting their output of work. The horses thus fed remained in good condition and even increased in weight.

The seaweed should be collected by preference towards the end of August and in September, the time it is richest in sugar. The hard leathery basal portion must be removed, and as it grows to a great length, it must be cut into pieces of 3-4 cm.

The author does not state the kind used.

A good stock-food can be made from seaweed by a patented process invented by D. CROUSIOE and H. F. WARNECKE of Stockholm. The seaweed is washed, steamed under pressure, pressed and dried under reduced pressure. The expressed liquid is concentrated at low temperature under reduced pressure, and the salts that crystallise out are separated by centrifugation. The brine is then mixed with the seaweed that has been treated, and the whole is dried under reduced pressure and made up into little cakes containing: water 5 % — protein 13 % — digestible carbohydrates 67 % — fat 1 % — fibre 9 % — mineral substances 5 %.

Mention should also be made of I. BILLITTERI's feeding experiments made in Sicily (2) with *Ulva Lactuca* (fig. 26) gathered on the shore of Palermo.

The seaweed was washed repeatedly and dried in the sun, the whole mass retained its brilliant green colour and was covered with mannose crystals. The stock to which it was given ate it readily and with evident pleasure.

I. BILLITTERI draws attention to the fact that seaweeds rich in salts and thus injurious are refused by animals; it is therefore necessary to remove the salts by frequent washings with water acidified by the addition of hydrochloric or sulphuric acid at 13 % or with fresh water containing little lime, or magnesium, since these

FIG. 26. — *Ulva Lactuca*.
From FRANCÉ, op. cit.

(1) Cf. *La vie agricole et rurale*, Vol. XVIII, No. 20. Paris, 1921.

(2) I. BILLITTERI. Alimentazione gratuita per equini, bovini, ovini, caprini, polli, conigli, ecc. Palermo, 1921, p. 8.

substances form insoluble compounds that hinder the seaweed from swelling up again.

The process is as follows: the seaweeds, as soon as they are gathered, are put into baskets which are left for 10 to 15 hours in running water, or else into barrels of water with a tap at the bottom. As soon as bubbles are seen rising from the surface of the seaweed, the barrels are emptied, the seaweed is again washed in fresh water and then dried in the open air. In this manner is obtained a dark-green mass that is easily cut and keeps well when dry provided it is often turned over (1).

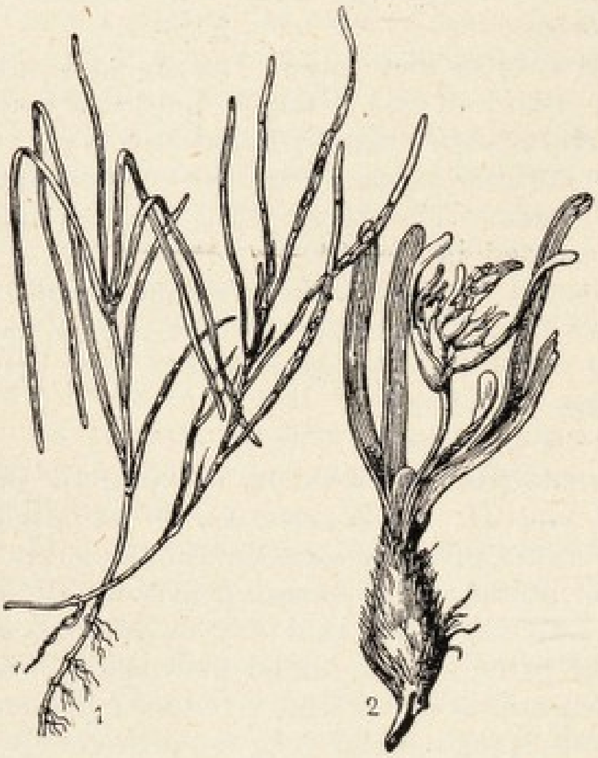


FIG. 27. — 1) *Zostera marina* 2) *Posidonia oceanica*.
From FRANCÉ, op. cit.

Carraghen or *Irish moss* (2). — This is composed of two species of seaweed *Chondrus crispus* and *Ch. mammilosus* that are collected for feeding to cattle, especially on the northern and western coasts of Ireland. They are very rich in mucilage, and when dry, form a horny looking mass, weighing light and dissolving almost completely in boiling water. In 100 parts of air-dried seaweed were found: dry matter 81.2 — nitrogenous matter 9.4 — N.-free extracts and fat 55.5 — crude fibre 2.2 — ash 14.2. Among the nitrogenous matters, algine is present; these seaweeds also contain another substance breaking up into galactose, glucose and fructose (J. SEBOR).

These seaweeds are easily digested. In America, a "seaweed flour" used in bread-making is obtained from them.

The glass-makers' seaweed (*Zostera marina*) (fig. 27) can also be used as a stock-feed in place of the species already described after it has been washed in fresh water, dried and chopped. The results of 2 analyses according to Dr. M. KLING (3) are as follows.

(1) Mr. P. GLOESS (in *Le Moniteur Scientif. Quesneville*. Paris, 1920, Part 936, p. 5) mentions that 1,200,000 tons of seaweed are collected on an average annually in Europe for the iodine industry, while a much larger amount is used for manure. The 1,200,000 tons, on burning, lose 180,000 tons of their original substance ; their nutritive value is equal to that of oats, while their monetary value is over one thousand million *liras*.

(2) POTT, E., op. cit., Vol. II, p. 349.

(3) KLING, Dr. M., op. cit., pp. 38.

	Unwashed seaweed	Washed seaweed
Water	8.6 %	10.2 %
Crude protein	13.8	14.4
Digestible protein	3.1	3.1
Crude fat	1.2	1.2
N-free extracts	40.7	40.5
Crude fibre	18.0	20.0
Mineral substances	17.7	13.7

The so-called Iceland Moss (*Cladonia rangiferina*) (fig. 28) which is a lichen, was used in 1915-1916 as a forage by JACOBI and HESSE and also by MORGHEN and his fellow-workers (1-2). The following are two different analyses of the plant.

	Analysis by POPP	Analysis by MORGHEN
Water	15.2 %	8.6 %
Crude protein	4.8	4.5
Crude fat	1.0	2.3
N-free extracts	25.8	42.4
Crude fibre	52.2	41.0
Mineral substances	1.0	1.2

This lichen was fed to a lamb and proved only poorly digestible. The substances assimilated were: organic matter 13.5 % — crude protein 21.1 % — fat 10.1 % — N.-free extracts 19.1 % — crude fibre 14.2 %. The lichen passed into the excreta almost without alteration. Sheep and swine will only eat it mixed with other forages having a pleasant flavour.

This lichen is rendered more appetising, especially for pigs, by being made to swell for 24 hours in a solution of potassium, and then washed in water to remove the products similar to tannic acid.

It is advisable to use Iceland moss only in cases of great dearth of roughage and to give it solely to sheep and cattle; horses or swine digest it less well and it does not suit them.

Special mention ought here to be made of the use of seaweeds as a stock feed in Germany during the war (3).

FIG. 28. — Iceland Moss.

From FRANCÉ, op. cit.

(1) KLING, Dr. M., op. cit., pp. 38.
(2) Cf. *Die Landwirtschaftlichen Versuchs-Stationen*, Vol. LXXXVIII, 1916.
(3) Cf. KLING, Dr. MAX, op. cit., p. 36.

Seaweeds were often found on the markets of Germany, sometimes fresh, otherwise dried and ground. The most common was *Fucus vesiculosus*, (fig. 29) but other kinds, such as *Fucus serratus*, *F. baldicus*, *Ascophyllum nodosum* etc., were also often to be seen; since however, they contain too much iodine (0.01-0.5 % of the dry matter) they did not give good results: the greater part of the iodine always had to be removed by washing in fresh running water.

Before the war, dried ground seaweeds used to be sold under the name of "Norgit" (because a large quantity of them came from Norway); during the war they were also known as "Tangit".

In wet seaweeds, where some of the water had dripped away during transport, M. KLING found: water 38 % — crude protein 10.5 % — crude fat 1.7% — N.-free extracts 26.8 % — crude fibre 8.9 % — crude ash 14.1 %.

The analyses of the dried ground seaweeds according to 3 different investigators were as follows.

	"Tangmehl" according to HONCAMP and GÖTTSCH	"Tangmehl" according to M. KLING	"Tangit" according to FÖRSTER
Water	11.4 %	11.8 %	14.3 %
Crude protein	6.1	6.5	9.1
Crude fat	3.1	3.4	1.9
N-free extract	56.8	42.0	52.2
Crude fibre	3.5	20.0	3.0
Crude ash	19.1	16.3	19.5

LOGES states that the dried, ground Norwegian "Norgit" contains: crude protein 8.8 % — crude fat 1.9 % — N.-free extracts 57.4 % — sodium chloride 5.6 %.

As the above figures show, these ground seaweeds are rich in N.-free extracts (starch, arabinose, *d*-galactose etc. but poor in protein and fat.

Up to 47 % of the N.-free extracts of the species of *Fucus* were digested, and 93 % of those present in *Ascophyllum*. The availability was much lower in the case of other species; the nitrogenous substances were never digested.

From the feeding experiments hitherto made, it appears that seaweeds chiefly suit cattle and pigs, but they must not be given alone. BECKMANN and ZUNTZ are of opinion that swine, like cows and sheep, could be fed on these seaweeds for months without any ill effects. The meat and fat of the animals thus fed were in perfect condition and free from any special smell of seaweed.

Owing to the volume and weight of the fresh seaweed it does not pay for transport, but should be eaten on the spot ; a wider market could however be found for the dried ground product of its price were lower.

8. — Weeds (1).

Under this head are to be understood all the wild herbaceous plants often found growing amongst cultivated plants, especially if the soil has not been kept clean during growth by weeding and hoeing.

Fig. 29. — *Fucus vesiculosus*.
From Francé, op. cit.

Weeds, however, from our point of view, cannot be regarded as useless, or even harmful, for many of them make excellent forage.

For example, the weeds growing amidst the winter cereals contribute largely to increase the nutritive property of the stubble when mown with it.

Some plants may be regarded as being in a sense the residues of different crops. These should be turned to account as soon as they are sufficiently developed.

During the war, the use of these weeds was greatly intensified everywhere, but especially in Germany, where they were the object of many experiments.

Thus, for instance, in the Palatinate, together with chopped vineshoots, the following species were fed to cows : the Lesser Bindweed (*Convolvulus arvensis*) — White Goosefoot (*Chenopodium album*) — Chickweed (*Stellaria media*) — Creeping Thistle (*Cirsium arvense*) — Common Sowthistle (*Sonchus oleraceus*) — Annual Mercury (*Mercurialis annua*).

When dried, the mineral composition of the above plants is between the following minima and maxima: nitrogen 2.77-4.45 % — phosphoric acid 0.85-2.01 % — potash 4.91-11.78 % — lime 1.03-5.30 %.

(1) Cf. : 1) Kling Dr. Max in *Die Landw. Versuchs-Stationen*, vol. 85, Part 6. Berlin, 1914. — 2) Weibull M. in *Landtmannen Erdschrift for Landtmän*, Year I, No. 17. Stockolm, 1918. — 3) Hansen et Mez in *Deutsche Landwirtschaftliche Presse*, Year 43, No. 22. Berlin, 1916.

All, except the last plant, can be fed fresh to dairy cows. These weeds can also be dug in (before their seeds ripen) as green manure.

Couchgrass (*Agropyrum repens*) (fig. 30) which is so relentlessly combated as a really injurious weed, makes a good forage having a nutritive value very near that of hay. When dried it contains: crude protein 8.3 % — fat 1.2 % — N.-free extract 62 % — fibre 16.5 % — ash 5 % — water 7 % — starch value 37.3, comparable to that of good hay. Live stock (especially horses and sheep) eat it readily.

Nettles (*Urtica dioica* and *U. urens*) (fig. 31) make an excellent forage which is fed dried, chopped and mixed with straw, especially to dairy cows, but also to sheep and swine. When chopped and boiled nettles form a stimulating poultry food. The average percentage composition of the two species of nettle is as follows (1).

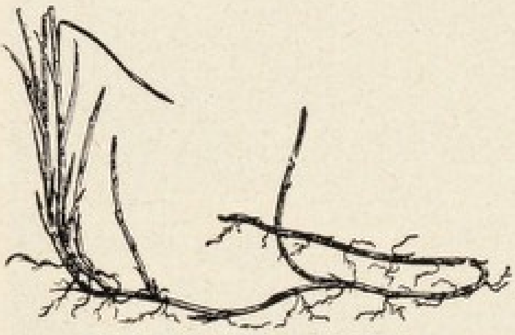


Fig. 30. — Couchgrass.

From Fron G. Plantes nuisibles à l'agriculture. Baillière, Paris, 1917.

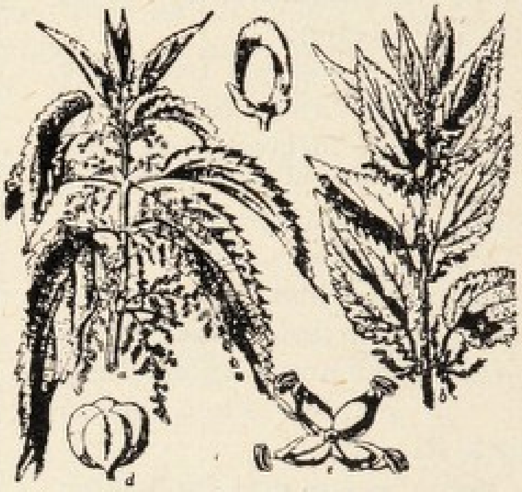


Fig. 31. — Nettle (*Urtica dioica* L.)

From Bruttini A., op. cit.

	Urtica dioica young	*Urtica urens* (in the dry matter)
Dry matter	88.6 %	—
Nitrogenous	18.3	19.9 %
Crude fat	7.7	1.8
N-free extract	38.8	41.4
Crude cellulose	10.6	24.0
Ash	14.0	13.0

In *Urtica urens*, the digestibility percentage of the nitrogenous matter was found to be 90.8. This plant contains stimulating substances that increase its nutritive power.

In Germany *nettle flour* has also been recommended as a stock feed; this meal was probably the residue of the extraction of the textile fibres

(1) Cf. Pott, E., op. cit., Vol. II, p. 298.

of the nettle, but it has now been recognised that the flour has no food value and must be regarded as roughage.

A distinction must, however, be drawn between the true residues of textile fibres which certainly have no food value and the leaves and fruits of the nettle. As *nettle-fibre* was largely used in Germany (1), during the war, these were obtained as waste products, and after drying they make a good stock-feed.

The following are 2 analyses of *Urtica dioica* :

	According to J. MACH	According to FÖRSTER
Water	12.4 %	9.6 %
Crude protein	21.1	24.9
Crude fat	4.4	2.5
Crude fibre	10.9	9.7
Mineral substances	20.0	19.6
N-free extracts	31.3	33.7

Its starch value is 43 % and its nutritive value is equal to that of white clover.

This feed suits all farm animals, and especially dairy cows, draught horses and poultry. It is best given to pigs cooked.

KLING expresses a fear that the nettle seeds which pass into the faeces may afterwards find their way to the fields in the manure, and thus the weed will be spread.

A. MOLLO (2) has recently made some experiments in feeding nettles to chicks. He obtained better results by mixing nettles and bran into a paste (using equal proportions of each) than when he substituted crimson clover for the nettles.

Among weeds, are to be considered Ferns, and especially the Bracken (*Pteris aquilina*) (fig. 32) a common plant on waste ground and in woods, though it is sometimes found on cultivated land, especially if recently cleared of trees.

FIG. 32. — Bracken.

From BRUTTINI A., op. cit.

(1) Cf. KLING, Dr. M., op. cit., p. 17.

(2) Cf. *Le Staz. Sperim. Agr. It.*, Vol. LV, Parts 10, 11, 12. Modena, 1922, p. 490.

According to WOLFF fresh ferns contain: water 25 % — ash 4.87 % — phosphoric anhydride 0.37 % — potash 1.86 % — lime 0.56 % — magnesia 0.31 % — sodium 0.18 % — sulphuric acid 0.17 % — silica 1 % — chlorine 0.37 % — and, according to various analysts: 0.9-4.0 % crude protein; 0.1-0.7 crude fat; 5.9-9.1 N.-free extract; 5.9-9.1 % fibre; 1.7-3.3 ash. A large part of the N.-free extract consists of starch. In the dried fern WÖLCHER has found: water 6.65 % — fat 4.70 % — protein substances 12.12 % — carbohydrates 46.84 % — fibre 24.43 % — mineral substances 5.25 %.

Bracken can be used as a stock feed, especially for pigs (up to 5-7 kg. being fed per 100 kg. of live-weight), it was employed for this purpose in many places during the war, but has long been fed to swine in Anjou and Brittany. The edible part of the plant is the root which is easily extracted; it has been eaten also by man in times of famine. Cows however do not like it on account of its bitter taste, but pigs after a time become used to its flavour.

FIG. 33. — Butterbur.

From FRANCÉ, op. cit.

Not more than 1 kg. per day of this root may be fed to young pigs, otherwise serious intestinal disturbance is produced. According to analysis made at the University of Königsberg the root contains: dry matter 42.1% — crude albuminoids 4 % — pure albumin 3.6 % — N-free extract 28.7 % — ash 1.7 %.

The stems and leaves of bracken are only suitable for litter, for protecting delicate plants from the cold, for packing material and for fuel (1).

HERBIG advises the young still unrolled fronds of 40-50 cm. in length as a feed for young pigs, first scalding the fronds in boiling water and mixing with a few potatoes.

The Butterbur (*Petasites officinalis Moench*) (fig. 33) (2). — Much use was made of this plant in Germany during the war, the leaves and inflorescences being fed, chopped and boiled, to swine.

According to the researches published by the Prussian Ministry of Agriculture, the leaves and inflorescences of the Butterbur make a very nutritious food that can be given to pigs without any addition of meal, or bran.

(1) Cf. A. BRUTTINI, Dizionario di Agricoltura, Milan, Dr. F. Vallardi, 1901, Vol. I.
(2) Cf. KLING, Dr. M., op. cit., p. 31.

The Water Soldier (*Stratiotes aloides L.*) (fig. 34) (1). — Even before the war this plant was used mixed with potatoes for a pig-feed, especially in the valley of the Oder, in Pomerania, where it grows very plentifully. During the war, it was naturally still more employed for this purpose.

From analysis made at the Köslin Agricultural Station with the object of directing the attention of agriculturists to *Stratiotes* it contains fresh : water 93.2 % — crude protein 1 % — crude fat 0.1 % — N-free extract 2.4 % — crude fibre 2.8 % — ash 0.5 %.

Many other weeds besides those already mentioned can be used as forage, as is proved by the fact that farm animals eat them of their own accord. Since it is impossible to enumerate all those plants which were more or less in general use during the war to supply the lack of ordinary agricultural and industrial foods-stuffs, we will name a few of the species most used in Germany for feeding, fresh or dried, especially to dairy cows.

FIG. 34. — Water Soldier.

From FRANCÉ, op. cit.

FIG. 35 — Lesser Bindweed.

From FRON G., op. cit.

Of the different species of weed studied by M. KLING (2), the Lesser Bindweed (*Convolvulus arvensis*) (fig. 35) proved the most valuable. The Annual Mercury (*Mercurialis annua*) is spite of its high nutritive qualities is refused by stock, so merits no further mention here.

Fungi can also sometimes be fed to stock (3): specimens infested

(1) Cf. KLING, Dr. M., op. cit., p. 31.

(2) Cf. KLING, Dr. M., op. cit., p. 32.

(3) Cf.: 1) KLING, Dr. M., op. cit., p. 101. — 2) POTT, Dr. E., op. cit., Vol. II, p. 355.

by larvae or species not used for human food being employed for the purpose.

POTT gives the average percentage composition of fresh fungi as follows: dry matter 12 — nitrogenous substances 3.5 — fat 0.2 — N-free substances 6 — crude fibre 1.4 — ash 0.9. Dried fungi have the following average percentage composition: dry matter 81.5 — nitrogenous matter 24 — crude fat 1.7 — N-free extract 42.6 — crude fibre 6.2 — ash 7.

According to DITTRICH, it is safe to feed to cattle, all the red, green, and yellow Agarics, all the *Lactarii*, all fungi with funnel shaped

FIG. 36. — *Boletus bovinus.*

FIG. 37. — *Russula emetica.*

or with broad scaly pileus, and *Boletus bovinus* (fig. 36). On the other hand, all *Amanita*, *Agaricus muscarius*, *Russula emetica* (fig. 37) and other poisonous fungi are to be avoided.

Fungi agree especially well with pigs, and should always be fed chopped, after being boiled for 10 to 15 minutes in a little water (which should be thrown away afterwards as a precaution), and mixed with other foods, at the rate of 0.5 kg. per head and per day. Fungi can be given to goats which eat them raw. Sheep eat fungi while grazing, but avoid those that are rotten or worm-eaten, and might probably disagree with them. Dried, cut up fungi make a good poultry food and in the opinion of E. POTT promote egg production.

The following table gives the percentages of some species of weeds.

Species	Water	Crude protein	Crude fat	N-free extract	Crude fibre	Ash	Pure albumin	Sand etc.	Lime	Phosphoric anydride
Convolvulus arvensis	83.1	3.6	0.6	6.8	3.2	2.7	2.2	0.8	0.30	0.15
Stellaria media	90.8	1.7	0.2	2.9	1.1	3.3	1.2	1.8	0.13	0.12
Cirsium arvense	88.2	2.4	0.2	4.4	2.2	2.6	1.4	0.5	0.60	0.10
Sonchus oleraceus	90.6	1.8	0.4	3.7	1.4	2.1	1.1	0.4	0.27	0.10
Mercurialis annua	88.0	2.8	0.4	4.4	2.0	2.4	1.7	0.4	0.47	0.14
Chenopodium album	88.8	2.6	0.2	3.4	1.7	3.3	1.6	0.7	0.38	0.14
Atriplex hastata	67.7	3.6	1.3	14.3	7.1	6.0	—	0.4	—	—
Polygonum lapathyfolium . .	71.7	3.1	0.7	14.0	8.1	2.4	—	—	—	—
P. aviculare	73.8	2.7	1.2	15.4	3.9	3.0	—	0.4	—	—

In conclusion, we give a list of wild plants forming good forage. Group I includes the species used during the war in Europe and especially in Germany (1).

Group II contains the species growing in a hot climate and mentioned as found in Tripolitania (2):

I. — *Calluna vulgaris* — *Phragmites communis* — *Phalaris arundinacea* — *Glyceria fluitans*, *G. aquatica* — *Fucus* sp. — *Ulva lactuca* — *Cetraria islandica* — *Cladonia rangiferina* — *Pteridium aquilinum* — *Typha* sp. — *Stratiotes aloides* — *Elodea canadensis* — *Potamogeton* sp. — *Lemna* sp. — *Triticum repens* — *Salix* sp. — *Polygonum cuspidatum* etc. — *Urtica dioica* — *Chenopodium album* — *Atriplex* sp. — *Stellaria media* — *Silene dichotoma* — *Vitis vinifera* — *Daucus Carota* — *Convolvulus arvensis* — *Symphytum* sp. —*Taraxacum officinale* — *Cichorium Intybus* — *Helianthus* sp.

II. — *Juniperus macrocarpa* — *Ephedra alata* — *Agropyrum junceum* — *Ampelodesmos tenax* — *Aristida plumosa* var. *floccosa*, *A. pungens*, *A. sativa* — *Bromus rubeus*, *B. villosus* — *Cynodon Dactylon* — *Dactylis hispanica* — *Imperata cylindrica* — *Lolium rigidum* — *Lygeum Spartum* — *Panicum turgidum* — *Pennisetum asperifolium* — *P. dichotomum* — *Phalaris minor* — *Stipa tenacissima* — *Scirpus littoralis* — *Asphodelus microcarpus* — *Muscari maritimum* — *Colligonum comosum* — *Emex spinosa* — *Anabasis articulata* — *Atriplex Halimus* — *Cornulaca monacantha* — *Halocnemum strobilaceum* — *Haloxylon articulatum* — *Salicornia fruticosa* — *Salsola tetragona*, *S. microphylla* — *Suaeda fruticosa* — *Traganum nudatum* — *Opuntia Ficus-indica* — *Frankenia laevis* — *Tamaris* var. sp. — *Helianthemum sessiliflorum* — *Capparis Sodada* — *Malcomia aegyptiaca* — *Matthiola pseudoxyceras* — *Moricandia subfruticosa* —

(1) Diels, op. cit.
(2) Trotter, op. cit.

Zilla microptera, Z. spinosa — *Delphinum nanum* — *Neurada procumbens* — *Alhagi maurorum* — *Anthyllis Henoniana* — *Astragalus baeticus, A. prolixus* — *Genista tunetana, G. Saharae* — *Lotus creticus.*

9. — Desert Plants.

Under this head come several species growing in hot, arid regions of Mexico, Texas etc., which E. O. Woston (1) has recommended for use in case of emergency: *Yucca elata, Y. glauca, Y. baccata, Y. macrocarpa, Y. brevifolia, Y. rupicola* — *Agave lechuguilla* — *Dasylirion Wheeleri, D. texanum* — *Nolina erumpens, N. microcarpa* — *Samuela faxoniana* — *Clistoyucca arborescens* — *Hesperoyucca Whipplei* — *Esperolae parviflora* — etc.

None of these wild plants have hitherto been used for stock-feeding; the forage obtained from them would be bulky and little nutritious, but it could be fed mixed with concentrates. As they are very difficult to chop, some suitable forage-cutters have been devised and put on the market; these will remove all objections on this score.

An interesting note on Soapweed (*Yucca elata* Engelm.) has been compiled by C. L. Forsling (2). In New Mexico, the leaves of this Yucca sometimes make up half the weight of the ration. The cattle will eat the leaves while on the plant and seize them either half-way up, or at the base, in order to avoid the sharp, hard point.

The flowers and the floral axis make a good stock-feed and are much liked by animals, they are moreover so succulent that the cattle need no water for several days after eating them.

The whole stem can be used if it is chopped up in small pieces in a machine made for the purpose: it should be fed with cottonseed meal etc., and with the cut-up leaves.

The respective percentage composition of the stem and leaves is as follows: water 54.7-42.3 — ash 3.6-3.6 — ether extract 1.1-3.1 — protein 1.3-4.5 — crude fibre 15.2-22.3 — N-free extract 24.1-24.2.

Among these desert plants must also be included various species of *Cactus* and *Opuntia*. The latter have already been treated of in No. 5, p. 112.

10. — Flower Bulbs.

The bulbs of many wild species form good cattle feeds, but these plants come under the head of weeds. One case, however, appears to require separate mention, viz., flower-bulbs that are past flowering or unsuitable in some other way.

(1) *U. S. Dep. of Agr., Bull. No.* 728. Washington, 1918.

(2) Forsling, C. L. Chopped Soapweed as an Emergency Feed for Cattle on Southwestern Ranges. *U. S. Dep. of Agr., Bull. No.* 745. Washington, 1919.

Shortly before the war, some experiments and analyses of these bulbs were made in Holland, with a view to employing them as a stock-feed (1). The following results were obtained.

Bulbs	Albuminoids	Fat	Starchy substances	Crude fibre	Water	Ash
Narcissus	2.7 %	0.3 %	29.6 %	1.8 %	64.5 %	1.3 %
Tulip	3.8	0.7	34.2	1.6	59.2	1.0
Hyacinth	2.4	0.1	24.3	1.0	71.2	1.0
Gladiolus.	3.0	0.2	25.4	1.4	68.5	1.3
Crocus.	7.2	0.3	42.2	2.7	48.9	1.1

These bulbs are therefore comparable to potato tubers. Assuming the digestibility of their starchy matter to be, like that of the potato, 90 %, the starch value of their dry matter would be: 25 for narcissus bulbs — 31 for tulips — 21.9 for hyacinths — 23.8 for gladioli — 38.8 for crocuses.

It should be noted that narcissus bulbs are poisonous on account of the *narcisine* they contain; hyacinth bulbs are also poisonous, but lose their toxic character on boiling: the same may be said as regards the other bulbs. During boiling, the water must be repeatedly changed.

Among the bulbs may be reckoned certain tubers of wild plants, like the Asphodel (p. 316), which are readily consumed by stock and in some places are used for human food (2).

11. — Screenings.

By the term screenings are understood the siftings of cereals and other grains; they consist mostly of foreign seeds.

These residues have been chiefly fed to poultry, but are often given to larger stock, though in the opinion of KELLNER it is a very debatable question whether they should be thus employed owing to the considerable amount of injurious foreign substances they contain.

They are however still used for this purpose and during the war owing to the scarcity of food of all sorts they were fed to stock in greater quantities.

Screenings are also made into dog-biscuits, while the dust from the sifters and winnowers is used as a fertiliser for meadows.

In Canada, a considerable amount of screenings is given to sheep. When ground, these residues are also made into molasses feeds (3).

(1) Cf. EZENDAM, J. in *Verslagen van den Landbowkundige Onderzoekingen der Ryksland-bouwproefstation*, No. XXII. The Hague, 1918.

(2) MARCHAND, G. in *Bull. de la Soc. d'Hist. Nat. de l'Afrique du Nord*, Vol. 13, No. 6. Algiers, 1922.

(3) I. R. DYMOND, *Dom. of Canada Dep. of Agric.* Grain Screenings. Ottawa, 1915.

In 1913, 100,000 tons of screenings (from wheat, oats, barley and flax) were obtained from the Central Silos of Canada.

Experiments made on different animals have proved the smallest weed seeds known as "black screenings" to be valueless, if not injurious: besides they impart an unpleasant flavour to the food containing them; and hence they are removed. The larger seeds can be fed to large and small live-stock at the rate of 50 to 60 % of the grain ration.

Screenings are best fed ground and should always be ground when given to mammals; if they are fed whole, many weed seeds pass into the excreta without losing their germinating power. "Black screenings" ought to be burnt.

An interesting study of screenings has been made by G. SAVINI (1) of the "R. Laboratorio delle Dogane e delle Imposte dirette" in Rome. He has examined a large number of samples of soft and of hard wheats from Italy and other countries. The commonest seeds belonged to the following species: *Agrostemma Githago — Avena sativa, A. fatua — Convolvulus arvensis — Galium tricorne — Gladiolus segetum — Hordeum vulgare — Lathyrus Aphaca — Polygonum Convolvulus — Secale cereale — Sinapis arvensis — Vicia sativa, V. villosa, V. sylvatica*, etc.

The amount of screenings varies from 2 gm. per kg. in a wheat from British India, to a maximum of 75 gm. per kg. in hard Moroccan wheat.

12. — Acorns, Beech-masts and other Forest Tree Fruits.

FIG. 38. — *Quercus robur*: branch, flowers and acorns.

From Dr. A. FIORI, op. cit.

Acorns (fig. 38) were chiefly regarded as a feed for pigs and generally eaten by them beneath the oak-tree in the forest. During the War, however, an attempt was made to use acorns for human food, especially as a substitute for coffee etc.

As a stock feed, acorns are poor in albuminoids, though rich in starch, and therefore cannot be given alone. They are very useful and produce no bad effects when added to the ration, provided their deficiencies are made good by plenty of green forage and of foods with a high nitrogen content. Under such conditions, they can safely be given to all farm animals, but if the supply of acorns is limited it is best to reserve them for the pigs.

In Germany, during the war, large quantities of meal were made from

(1) Cf. *Le Stazioni sperimentali agrarie italiane*, Vol. LII, Parts 7-8-9. Modena, 1919.

whole acorns (undecorticated and dried); this kept better than the acorns themselves and had the following composition:

	According to Kling	According to Kaselhoff
Water	10.5 %	10.1 %
Crude protein	7.2	6.3
Fat	3.4	3.3
N-free extracts	65.5	69.4
Crude fibre	10.5	7.1
Ash	2.9	3.8

Sheep and pigs eat this food at once, but horses and cattle have to be gradually accustomed to it.

The average amounts of acorns that can be fed daily to stock are as follows:

	Fresh acorns lbs.	Dried acorns lbs.
Horse weighing 1200 lbs.	8.8	5.5
Ox » 1300 to 1550 lbs.	13.2	7.7
Dairy cow » 1100 to 1300 »	8.8	5.5
Sheep	1.8	1.1
Swine	about 3	about 2

For horses a double ration of acorn as compared with oats is required, but after acorns have been fed for a month they should be left off for a week. Cattle and horses take the acorns raw and decorticated, but they are fed to pigs in the form of a coarse flour mixed with potatoes, or still better cooked with potatoes.

Dried and ground acorns can be given to poultry instead of grain and bran, but as their nutritive value is much below that of either of these two substances, the ration must be supplemented by matters richer in albuminoids, such as meat meal, oil cakes, etc.

Mr. H. Cranfeld fed acorns to fowls for 4 weeks without observing any ill effects. They are a little constipating, it is true, but this can be corrected by giving fish meal which is laxative. Acorns have no injurious effect upon egg production. The daily ration determined by the above investigator was 57 gm. per fowl.

Beechnuts (or mast) which are fairly nutritive and easily digested may be added to the acorns. They contain "fagine", but this is only toxic in large quantities. Horses can safely eat 3 kg. a day; beechmast is however mainly regarded as food for pigs, and they are turned out to eat it under the trees (See *Oilcakes,* p. 156.)

In addition to acorns and beechmast, the following fruits, although usually neglected by agriculturists, can also be fed to stock.

Fruits of the Elm (*Ulmus campestris*) (fig. 39). — These are very rich in albumin and fats; they contain relatively little crude fibre and a very small amount of tannin.

Elm fruits are specially suited to dairy cattle and to horses. After being dried, ground and scalded, they have been successfully fed to pigs.

The following are two analyses of the fruits of *Ulmus campestris*:

	According to KLING	According to BEYTHIEN and his collaborators
Water	11.6 %	9.9 %
Crude protein	24.6	20.8
Crude fat	15.3	31.1
N-free extract	15.0	18.0
Crude fibre	20.7	11.0
Ash	12.8	9.2

Fruits of the Ash (*Fraxinus excelsior*). — These consist on an average of 56 % seed and 44 % integument. They can be fed in their natural condition to horses, but must be dried and ground, or else made into a mash, before they are given to pigs.

The composition of the whole fruit, seed and integument respectively, is thus given by KLING.

	Whole fruit	Seed	Integument
Water	15.0 %	11.8 %	19.2 %
Crude protein	11.1	16.5	4.0
N-free extract	42.3	43.6	40.6
Crude fat	10.3	17.3	1.3
Crude fibre	17.2	7.9	29.2
Ash	4.1	2.9	5.7
a) Albumin	10.2	15.4	3.4
b) Tannin	0.12	0.11	0.14

Fruits of the Common Lime (*Tilia europaea*) (fig. 40). — These are specially suited to horses and cattle; their composition is as follows:

Water	68.1 %
Crude protein	3.6
Crude fat	3.0

N-free extracts	9.7
Crude fibre	13.5
Ash	2.1
Starch value = 17-18.	

Fruits of the Common Hornbeam (*Carpinus Betulus*). — As these contain much crude fibre, they must be ground and can only be given to cattle and horses.

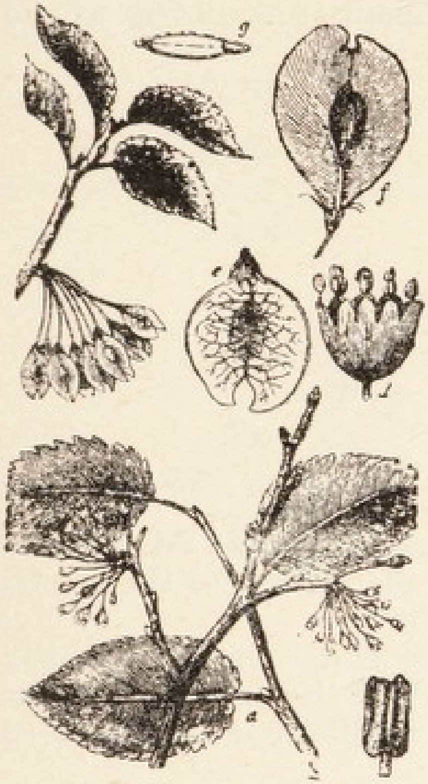


FIG. 39. — Elm : branch, flowers and fruit.

From BRUTTINI A., op. cit.

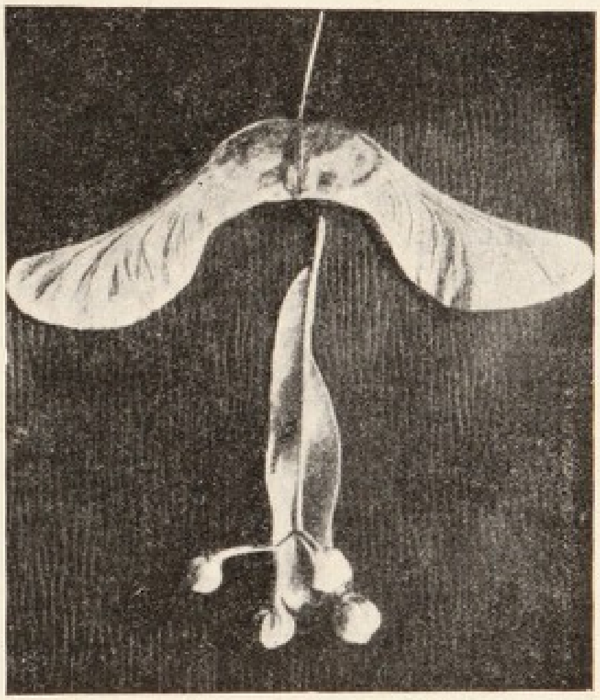


FIG. 40. — Fruits of Maple (*above*) and of Common Lime (*below*).

From FRANCÉ, op. cit.

Their composition according to two analyses is:

	KLING'S analysis	MÜLLER'S analysis
Water	9.5 %	5.1 %
Crude protein	6.8	6.5
Crude fat	3.6	6.7
N-free extract (tannin 0.09 %)	44.7	22.4
Crude fibre	32.9	56.4
Ash	2.5	2.9

Fruits of the Asparagus (*Asparagus officinalis*). — When dried and ground, these make an excellent stock-feed. The whole berry contains

63.5 % water, the pulp contains 71.2 % and the seeds 65.6 %. From feeding experiments, it has been found that lambs digest 65.5 % of the crude protein ; 89.5 % of the N-free extract and 46.7 % of the crude fibre.

The starch value of the dried berries is 64.6 %. The percentage of digestible albuminoids is 7.7 %. Pigs digest these berries to a less extent than lambs.

Fruits of the Mountain Ash (*Sorbus Aucuparia*) (fig. 41). — These can be fed to poultry and swine. Their composition according to two analyses is as follows.

	I	II
Water	77.1 %	75.1 %
Crude protein	1.1	1.8
Crude fat	1.4	1.2
N-free extracts	17.7	18.8
Crude fibre	2.0	1.4
Ash	0.7	1.7

From the *berries of the Laurel* (*Laurus nobilis*) (1) an oil for condiment, for perfumery etc., is extracted in the district of the Garda, at Gargnano (Italy).

The berries are treated while quite fresh and are boiled with water in vats containing 1600 kg. for at least 10 hours when the oil rises to the surface, is skimmed off, put into barrels and decanted to obtain it pure.

The exhausted berries are mixed with straw and hay residues and fed to cattle, horses, mules and donkeys.

Prof. FACHINI states that the berries, without the stones, contain: 27 % water; 26.15 % oil ; 7 % crude protein ; 25 % fibre ; 3.50 % ash ; 10.43 % ; phosphoric acid in ash — 10.43 % N-free extract.

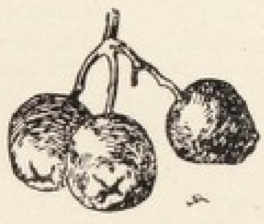


FIG. 41. — Fruits of the Mountain Ash.

From CORREVON H. Nos arbres dans la nature. Atar, Genève, 1920.

Fruits of the Hawthorn (*Crataegus Oxycantha*) (fig. 42). — These contain 20 % seed and 80 % pulp. Fowls will eat them, but they have not yet been given to larger animals. Haws have been used in Germany like many other substances, as a substitute for coffee. Their percentage composition is as follows :

FIG. 42. — Hawthorn.

From BRUTTINI A., op. cit.

(1) Cf. U. BRIZZI. Il lauro. *Assoc. It. Pro Piante Med. e Aromatiche*, Milan, No. 9, 1921.

	Whole fruit	Pulp	Seeds
Water	70.0 %	80.0 %	29.2 %
Crude protein	1.4	0.9	4.1
N-free extracts	0.8	0.5	3.0
Fat	19.4	12.4	37.3
Crude fibre	7.5	4.6	25.4
Ash	0.9	0.6	1.0

Fruits of the Dwarf Elder (*Sambucus racemosa*) (fig. 43). — These are fed to poultry. The dried berries contain 11 % of water, 26.3 %

FIG. 43. — Dwarf Elder : berried branch.

From CORREVON H., op. cit.

fat and 10.8 % crude protein. F. MACH advises the oil being extracted from the dried seeds, and the residue fed to stock. According to this author, the composition of the berries and their peduncles is as follows :

Water	81.4 %
Crude protein	2.3
Crude fat	5.5
N-free extract	4.8
Crude fibre	5.0
Ash	1.0

13. — Horse Chestnuts (1).

The seeds of the horse-chestnut (*Aesculus Hippocastanum* L.) (fig. 44) which had been regarded as useless, aroused a good deal of interest during the war and many new or modified processes were tried in order to render them fit, not only for a stock feed, but also for human consumption. These chestnuts cannot be eaten without being first treated with cold water, either pure or acidified, or with boiling water, in order to remove the bitter principles they contain which are distasteful to animals, and sometimes, as in the case of saponine, extremely injurious to them.

FIG. 44. — Horse-chestnut: branch, flowers and fruit.

From Dr. A. FIORI, op. cit.

WOLFF states that these chestnuts when fresh contain: water 49.3 % — ash 1.2 % — nitrogen 0.69 % — phosphoric anhydride 0.27 % — potash 0.71 % — lime 0.14 %.

According to GOTTWALD, however, their percentage composition is as follows: dry matter 91.63 — nitrogenous substances 7.81 — fat 7.22 — fibre 2.80 — carbohydrates 79.22 — mineral substances 2.45.

GORIS says the dry cotyledons contain: fat 2-3 % — nitrogenous substances 6-7 % — starch 20-30 %. There is also a small quantity of oil present (see, p. 340). They are sufficiently digestible, 85 % of the fat, up to 93 % of the N-free extract being available, but only 60 % of the protein.

The albumin after it has been washed to remove the bitter principles produces a fine white flour free from any smell or taste. This can be used not only as a stock-feed, but also in the manufacture of starch and alcohol as well as of alimentary pastes, for which purposes it was employed at the College of Pharmacy of Paris during the war.

The Académie des Sciences of Paris requested I. DECHAMBRE to draw up a report on the experiments he had conducted at the Grignon National School of Agriculture. The results of his investigations show that fresh, crushed horse-chestnuts can be fed to sheep at the rate of 0.5 to 1 kg. per head and per day. When steamed, or boiled, cattle will eat them, and they may be fed (especially in the

(1) Cfr.: 1) A. BRUTTINI, Dizionario di Agricoltura, Vol. I, Milan, F. Vallardi, 1901. — 2) *Comptes rendus de l'Académie des Sciences*, Vol. 165, Nos. 10 and 32. Paris, 1917. — 3) *Illustrierte Landw. Zeitung*, Year 34, Nos. 42-43. Berlin, 1914.

case of steers that are being fattened) to large-sized animals up to 3 kg. per head per day. Cows also eat these chestnuts readily and without any injurious effects upon their milk. When horse-chestnuts are given to swine, it is best to treat them with water and then dry and grind them ; as much as 1 kg. may be fed per head and per day. The chestnuts must be ground, and the meal cooked and made into a paste is used as a poultry feed.

It is best to mix horse-chestnuts with molasses, or with beet leaves and slices etc.

TISSERAND says that horse-chestnuts have alwaysf ormed part of the normal ration of the flocks at the Rambouillet Sheep-Farm.

As regards their relative nutritive value, 0.5 kg. of fresh chestnuts are equivalent to 1.5 kg. of mangolds in feeding sheep.

In Germany, HANSEN REISCH has tried feeding flakes of horse chestnuts, previously freed from all bitter principles, to lambs (at the rate of 1.2 kg. per day and per 100 kg. of live weight) and to cows (2 and 4 kg. per head and per day). The digestible part contains : protein 4.01 % — fat 3.34 % — N-free extract and Fibre 63.02 % — starch value 72.4.

14. — Unspecified Seeds.

Under this head, we shall treat only of some species of seed which until the war were turned to no special account, all seeds usually fed as concentrates to large and small stock being naturally passed over.

Owing to the great scarcity of stock feeds during the war, efforts were made to make use of seeds that had before been almost entirely neglected (fig. 45). In this brief account, we will not mention seeds that have already been treated of in special chapters viz., grape seeds, the kernels of cherries and other stone-fruits, cereal screenings etc.

Elm seeds (*Ulmus campestris*) (1). — The seeds in the samarae can be fed enclosed in the pericarp to ruminants but the pericarp must be removed by rubbing the seeds between the hands or by some other means before giving them to poultry, which eat them with avidity.

Elm seeds contain an oil similar to that obtained from copra. Their chemical composition is as follows :

(1) Cf. A. BEYTHIEN and other authors in *Zeitschrift für Untersuchung der Nahrungs und Genussmittel*, Vol. 32, p. 315, 1916.

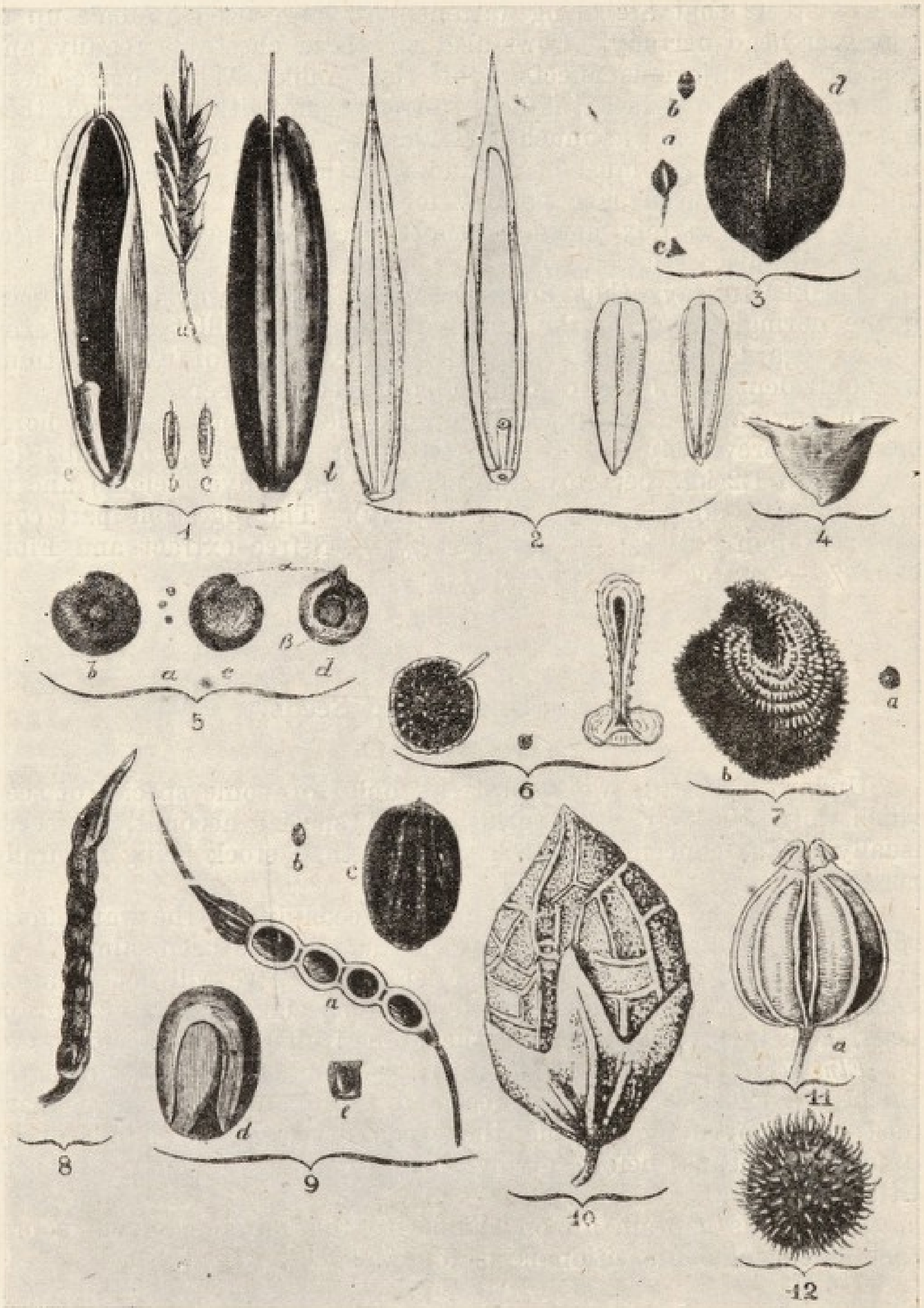


FIG. 45. — Weed seeds, etc.

1. Brome grass (*Bromus secalinus*). — 2. Quitch grass (*Triticum repens*). — 3. Bearbind (*Polygonum Convolvulus*). — 4. Spinach (*Spinacia oleracea*). — 5. Goose foot (*Chenopodium album*). — 6. Spurry (*Spergula arvensis*). — 7. Corn-Cockle (*Agrostemma Githago*). — 8. Wild Mustard (*Sinapis arvensis*). — 9. Charlock (*Raphanus raphanistrum*). — 10. White melilot (*Melilotus alba*). — 11. Parsley (*Petroselinum sativum*). — 12. Goose grass (*Galium Aparine*).

From Dr. L. WITTMACK. Landwirschaftliche Samenkunde. Berlin, P. Parey, 1922.

	Whole samara	Seed	Wings
Water	9.94 %	6.45 %	12.66 %
Crude protein	20.78	41.99	4.27
Crude fat	18.01	23.47	13.55
Crude fibre	10.94	6.34	14.52
N-free extracts	31.10	12.78	45.36
Ash	9.33	8.70	9.64
Nutritive value	108.70	144.30	81.00

Currant Seeds. — K. ALPERS (1) suggests that the oil should be extracted from these seeds and the residue fed to stock.

The seeds contain: water 11.42 % — crude protein 14.92 % — ether extract 23.64 % — crude fibre 22.83 % — ash 2.78 %.

Sugar-beet seeds that have lost their germinating power can be ground and given without further treatment to stock. Their nutritive value is $^2/_3$ of that of wheat bran.

They contain: crude protein 11.63 % — crude fat 4.42 % — ash 8.96 % (2), and are chiefly fed to cattle crushed and mixed with chopped straw, or chaff. They can also be given to horses, but are only suitable for swine when ground and mixed with other food-stuffs poor in crude fibre.

The screenings of sugar-beet seeds are also used. These residues contain fragments of leaves, flowers and some glomerules. When reduced to flour, the screenings are employed in the preparation of molasses feeds. Their digestibility coefficients in the case of lambs are: crude protein 57.2, fat 63, N-free substances 45. Their starch value is 19.

Parsley seed (fig. 45). — Seed left unsold or damaged seed was fed to stock. When ground, these seeds can be given as a stimulating food, but only in rather small quantities. They should be mixed with foods containing no stimulating matters, such as potatoes, sugar-beets, damaged hay, etc. The following is their percentage composition: water 11.5 — crude protein 13.75 — crude fat 23.40 — N-free extract 36.04 — crude fibre 6.50 — ash 8.81 (3).

Nettle seeds (*Urtica dioica, U. urens*). — POTT (4) says that, in Denmark, the seeds of the common nettle are collected to be given to horses as a supplementary food.

They are dried and then pounded; a handful being fed with oats, morning, and evening 3 times a week. These seeds impart a gloss

(1) Cf. K. ALPERS, Johannisbeerkerne und deren Oel, in *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, Vol. 32, Part 11, p. 499. 1916.

(2) (3) Cf. *Landw. Jahrbuch für Bayern*, Year 6, Nos. 11-12. Munich, 1916.

(4) POTT, op. cit., Vol. II, p. 731.

to the horses' coats. If boiled, they are excellent for poultry, and promote egg production.

Seeds of the Spurry (*Spergula sativa, S. arvensis* (Fig. 45), *S. maxima*). — In Denmark, the seeds of the spurry are collected from wild plants and ground, after which they are fed to dairy cows at the rate of 3 kg. per head and per day; this amount, however, according to POTT, makes the butter soft.

These seeds are fed to cattle also in the Rhine district and in Belgium. Their average percentage composition is: dry matter 89 — N-free substances 13.7 — crude fat 10.7 — N-free extract 54.6 — crude fibre 6.8 — ash 3.2.

Seeds of the Plantain (*Plantago lanceolata* (fig. 46),

FIG. 46. — Plantain (*Plantago lanceolata*).

From CLARK G. K. and FLETCHER J. Farm Weeds. Ottawa, Dept. of Agr., 1916.

FIG. 47. — Plantain (*Plantago major*).

From MIN. FED. DE L'AGR. B. n. 5-6, Ottawa, 1911.

P. media, P. major) (fig. 47) (1). — These seeds are often obtained in considerable quantities as a result of sifting and cleaning forage plants, many plantains growing among forage species.

The seeds are fed crushed and boiled, or very finely ground, to ruminants, sheep, and pigs as a supplementary ration, especially in Silesia, where they are much prized. They contain on an average: dry matter 88.8 % — nitrogenous matter 16.2 % — N-free extracts 38.6 % — crude fibre 22.5 % — ash 3.5 %.

Seeds of Sorrel Dock (*Rumex patientia* L.) (fig. 48). — This weed is sometimes cultivated like the sheep-sorrel. According to HOFFMEISTER, its seeds contain: dry matter 84 % — nitrogenous matter

(1) Cf. POTT, E., op. cit., Vol. II, p. 732.

— 12.6 % crude fat 5.2 % — N-free extract 49.5 % — crude fibre 8.4 % — ash 8.2 %.

Seeds of the Wild Mustard (*Sinapis arvensis* L.) (Fig. 45) (1). — The wild mustard is a weed that chiefly invades the fields of oats and clover; it can be destroyed by watering with copper sulphate, or ferrous sulphate.

The seeds contain a small quantity of the essential oil of mustard, this is removed by crushing them and boiling them in water. Their average composition is as follows: dry matter 92 % — nitrogenous substances 25.9 % — crude fat 26 % — N-free extracts 21.8 % — crude fibre 9.8 % — ash 6.5 %.

Seeds of the Corn-Cockle (*Agrostemma Githago*) (fig. 45, 49) (2).

FIG. 48. — Sorrel.

From BRUTTINI A., op. cit.

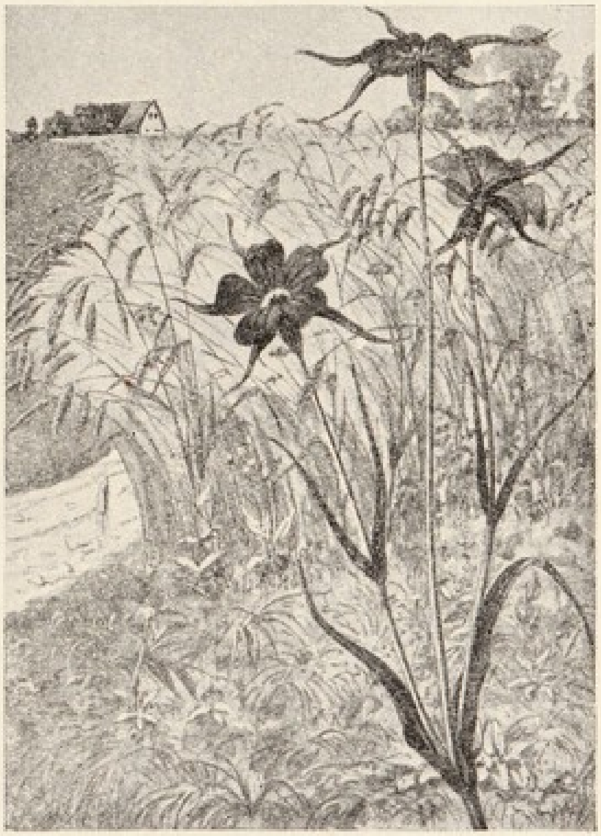


FIG. 49. — Corn-Cockle.

From FRANCÉ, op. cit.

— The seeds of this common weed of cereal fields often occur in wheat screenings. The embryos contain *gitagine* which is poisonous. In order to render the seed innocuous, the integument and embryo must be removed after which it makes an excellent stock-feed. The poison may also be eliminated by crushing the seeds and by roasting, or boiling, them in water. They contain on an average: dry matter 88.2 % — nitrogenous substances 15.2 % — crude fat 5 % — N-free extract 58.1 % — crude fibre 6.2 % — ash 3.7 %.

(1) Cf.: 1) POTT, E., op. cit., Vol. II, p. 761. — 2) BRUTTINI, A. Dizionario di Agricoltura, op. cit., Vol. II.
(2) Cf.: 1) *ibid.* — 2) *ibid.*

These seeds can be given to healthy adult animals up to 5 kg. per 1,000 kg. of live weight. Poultry may be fed 7 gm. per head and per day.

Seeds of the Darnel (*Lolium temulentum*) (fig. 50). — The seeds of the darnel, a plant often met with growing among cereals, are frequently mixed with wheat grain etc. They are poisonous in certain cases, as they contain an alkaloid *temuline*, or *temulentine* which may induce vertigo and paralysis in man and carnivorae but seems harmless to cattle, pigs and ducks, if the results of the experiments made in this direction are to be believed (1). The unripe seeds appear to be innocuous.

Fig. 50. — Darnel.

From Clark and Fletcher, op. cit.

It is however best to combat this weed and avoid giving the seeds to live-stock.

The seeds of some of the common Rubiaceae that grow in the fields and hedges such as *Galium Aparine* (Goosegrass) (fig. 45, 51) *G. Vaillantii* and *G. tricorne*, are found among the residues of cereal sifting and are regarded as screenings (see p. 133) but as they have been the subject of separate treatment in Hungary by I. Bernatsky (2), it seems advisable to mention them here. These seeds are regarded as a good stock feed, but since they are very hard it is usually necessary to grind them. They can, however, be fed whole to poultry. These seeds contain 1 to 2 % of oil.

Among the residues of tropical plants, *Hevea* seeds take an important place on account of the very large quantities that can be collected but in actual value and real use they are much inferior to the chief product of this tree, viz. india-rubber.

During the war, especially, experiments were made with *Hevea*

(1) Cf. Pott, E., op. cit., Vol. II, p. 771.
(2) Cf. Kiserletugyi Kozlemények, Vol. XVIII, Part 4. Budapest, 1915.

seeds, as well as with other substances, to determine their food value. Excellent results were obtained with *Hevea* seeds made into cake after the extraction of their oil (1).

The first researches on these seeds were carried out at the Imperial Institute in 1903, a drying oil being obtained (2).

FIG. 51. — Goosegrass. Branch, flowers and fruits. From DR. A. FIORI, op. cit.

The *Hevea* begins to bear seed when 4 years of age. The seeds consist on an average of 50 % kernel and 50 % shell. Their average oil content is 20 %, or over.

The cake made from these seeds is a valuable stock-feed. It is fed dry or soaked to cattle which eat it readily even if given alone, and has proved an excellent feed for fattening butcher's beasts, being little inferior in this respect to flax.

The experiments hitherto made have been so very satisfactory as to make it worth while to enter into some arrangement with the manufacturers of seed oils with a view to the regular exploitation of these *Hevea* residues so long regarded as useless.

The analyses obtained at the Imperial Institute are as follows.

	Cake, or meal, made from whole undecorticated seeds	
	Extraction	Pressure
Moisture	8.24 %	11.52 %
Crude protein	17.50	15.31
Fat	4.48	6.08
Carbohydrates etc. (by difference)	32.29	31.97
Fibre	34.86	32.54
Ash	2.63	2.58
Nutritive ratio	1 : 2.4	1 : 3.0
Food units	87	85

Lupin seed residues (fig. 52). — Seeds of poor quality that are unsuitable for sowing can be used for making the following concentrated food prepared according to BURGER's method. They are ground

(1) Cf. FREIRE, D. in *Bulletin commercial de la Section des affaires économiques du Ministère des Relations extérieures de la République des Etats-Unis du Brésil*, No. 8, Rio de Janeiro, 1919.

(2) *Bull. of the Imperial Institute*, Vol. XVII, No. 4, 1919.

and put into tubs filled with water; a current of steam is then introduced until the water boils; then the seeds are left until fermentation sets in, which process hastens the loss of the bitter taste. At the end of 12 hours, some more water is added, this is later drawn off and the liquid thus obtained, which has considerable fertilising properties, is sent to the liquid-manure pit. The mass is steamed for ½ hour, thoroughly washed for 24 hours in cold water, dried in an autoclave and ground. The finished product can be fed to dairy cows at the rate of 2.6 kg. per head and per day.

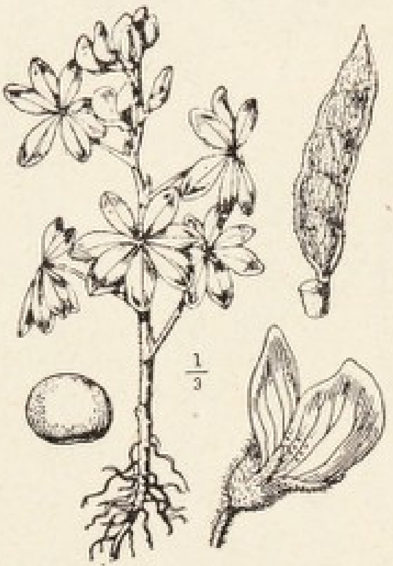


Fig. 52. — Lupin (*Lupinus albus*): whole plant, flower, fruit and seed.

From Dr. A. Fiori, op. cit.

Another way, devised by Augustin, for using refuse lupin seeds that have ripened badly and are mouldy, is to leave them to swell for 24 hours in cold water, for this purpose they are placed with potatoes into partially filled bags, steamed in a potato-steamer, and kept under water 12 to 24 hours. They are fed fresh to stock at the following rates per head and per day: horses 1.5 kg — draught oxen 1 kg. — fattening oxen 1.5 kg. During the removal of their bitter properties, the lupins undergo a certain amount of loss which has been estimated by Messrs. Gerlach and Kundrass as follows (1): water 22.2 % — crude protein 11.4 % — pure albumin 4 % — digestible albumin 3 % — fat 0.1 % — N-free extracts 27 % — pure fibre 4.5 % — ash 44.1 %.

The following are the results of 3 analyses.

	Analyses of Gerlach and Kundrass		Burge's analysis
	Untreated lupins	Lupins freed from bitterness and dried	Lupin seed residues
Water	14.4 %	10.2 %	5.3 %
Crude protein	30.0	34.1	42.1
Crude fat	3.9	5.1	3.8
N-free extracts	38.1	35.7	19.0
Crude fibre	10.0	12.3	25.9
Mineral substances	3.6	2.6	3.9

Cotton seeds. — It is well-known that cotton-seed cake, largely used as a stock-feed and a fertiliser, is made from decorticated

(1) Kling, Dr. M., op. cit., p. 83.

cotton seeds from which the oil has been extracted. Not all agriculturists however have at their disposal a hulling machine with which to prepare this concentrated feed for their stock, but they can adopt the method employed by many farmers in Queensland who boil the seed in water for 15-20 minutes and give the freshly-boiled seeds every day, especially to dairy cows, mixed with some dry, or green bulky fodder (1).

It may be useful to give the percentage composition of the seeds of the following other species of wild plants of which the seeds were recommended for use as a stock feed during the war (2):

	Water	Crude protein	Fats	N-free extracts	Crude fibre	Ash	
Bromus secalinus (fig. 45) . .	14.2	8.9	2.1	63.3	7.2	4.3	Cattle, Horses, Swine.
Bromus arvensis	14.2	9.7	1.0	57.5	12.2	5.4	id. id.
Chenopodium album	12.2	15.3	6.5	40.7	20.3	5.0	
Triticum repens	13.3	8.8	2.8	60.9	9.5	4.7	
Centaurea cyanus	12.9	12.8	12.3	43.7	15.5	2.8	with caution.
Convolvulus arvensis	10.3	18.5	6.0	47.6	14.0	3.6	
Galium Aparine (fig. 45) . .	9.7	11.3	4.2	64.4	6.6	3.8	
Raphanus Raphanistrum . . .	6.9	10.0	6.8	43.3	30.4	2.6	
Campanula Rapunculus(fig. 45)	7.1	23.6	25.6	22.2	10.1	11.4	
Saponaria Vaccaria	12.3	12.9	3.0	64.8	4.8	4.2	
Sinapis arvensis	7.3	28.2	28.2	22.9	9.6	3.8	boiled in water.
Erysimum orientale	8.5	27.3	28.2	25.0	6.9	4.1	
Melilotus alba (fig. 45) . . .	10.3	33.2	2.6	36.2	13.3	4.4	ground for all stock
Vicia sepium	—	—	—	—	—	—	contains HCN ; not to be used.
Vicia hirsuta	9.7	25.3	0.6	55.4	6.3	2.7	
Polygonum lapathifolium . . .	16.0	12.6	5.2	49.6	8.4	8.2	
Polygonum Convolvulus(fig. 45)	10.9	10.5	2.1	68.5	6.4	1.6	
Spergula arvensis (fig. 45) . .	10.1	13.0	10.8	52.1	9.4	4.6	forage value = cereals.
Trifolium prat., Medicago sat. (residues)	—	20.7	7.7	—	—	—	seed, soil, etc.
Medicago lupulina (residu s).	—	32.0	5.3	—	—	—	id. id.
Spinacia oleracea	8.5	11.0	3.9	50.6	21.4	4.6	used like beetseed.
Iris Ppseudoacorus	4.6	9.7	14.1	26.3	43.2	2.1	for poultry.
Rosa canina	7.7	10.1	9.3	35.9	34.8	2.2	ground, for cattle and horses.
Acacia sp.	10.3	38.8	10.2	23.1	13.6	4.0	for all stock.
Acer platanoides (*)	9.9	24.4	19.4	33.6	6.4	6.3	
Acer Pseudoplatanus (*) . . .	14.3	20.0	13.0	27.4	7.9	8.7	mixed with other forage.

(*) These seeds are fairly rich in tannic acid (0,74-0.16 %). No efficacious means of removing it are yet known.

(1) Cf. *Queensland Agr. Journ.*, Vol. XVI, No. 5, Brisbane, 1921.
(2) Cf. KLING Dr. M., op. cit., p. 151

15. — Waste from Potatoes (1).

Potatoes as a Stock-feed. — When potatoes are mouldy, and hence unsuited for human consumption, they can be given to swine, or used for making alcohol.

When intended for pigs, especially if it is desired to keep the potatoes until after May and there is no means of drying them artificially, the tubers should be stored by first steaming them and then placing them in trenches with air-tight walls. If all air is excluded, losses during storage can be greatly reduced by using the pure cultures of lactic ferment furnished by the Berlin " Institut für Gärungsgewebe " (2).

Drying is however a much better method for keeping potatoes and was practised for the first time, in 1890, in Germany.

By 1915, there were already in that country 721 drying establishments able to deal with 23,000,000 m. tons of potatoes. In this process, the tubers are first cut into slices (" Schnitzel ") of different shapes which are dried by a current of hot air. Potato flakes are also first steamed and are then pounded to a paste which is dried by 2 hot cylinders. In order to obtain flour of crushed potatoes (" Kartoffelwalzmehl ") the tubers are ground and then passed through a sieve. This flour is used for human food, generally in bread making. The residue that clings to the sieve is mixed with the parings (to which a little of the pulp still adheres) and makes a good stock feed (" Kartoffelkleie ").

In Germany, potatoes were formerly always given to swine, but during the war, they were fed fresh, or dried, to cattle, sheep, and even horses ; later, their use for this purpose was forbidden and only spoilt potatoes might be used for pigs and poultry.

During the war experiments were made at the Berlin University with the potato parings forming part of kitchen refuse (3). These parings, after having been dried and ground, were fed to young pigs weighing 30-40 kg. at the rate of 0.5 kg. per head and per day. The protein and fibre contained in this residue were difficult to digest but their digestibility coefficient was little lower than that of dried potatoes. The food value of the parings is about 80 % of that of the potato slices.

As regards their chemical composition, *potato haulms* much resemble good meadow hay, if they are cut immediately before the tubers are lifted and are then dried. The haulms can also be made into silage.

According to an analysis made in Germany (4), dried potato haulms have the following digestibility values : organic matter 64 %

(1) Prof. Dr. J. Hansen and Dr. Fr. Arnoldi, *Beiträge zur Kriegswirtschaft* : Die Kartoffeln in der Kriegswirtschaft, Berlin, R. Hobbing, 1916.

(2) For the preparation of sour potatoes, see also : Part 2, of the *Arbeiten der Gesellschaft zur wirtschaftlich zweckmässigen Verwendung der Kartoffeln*, Berlin, W., 9 Eichhornstrasse.

(3) Cf. *Deutsche Landw. Presse*, Year 43, No. 31. Berlin, 1916.

(4) Cf. *Landw. Jahrbücher*, Vol. 46, Part I, Berlin, 1914.

— crude protein 57 % — crude fat 53 % — crude fibre 66 % — N-free extracts 68 % — calories 63.

The haulms, after having been silaged for 2 months, were divided into two lots, one of which was kept fresh, and the other dried, their percentage composition was respectively as follows: organic matter 61.8-84.7 — crude protein 62.3-55.8 — crude fat 66.4-77.4 — fibre 49.3-64.8 — N-free extracts 62.7-66.7 — calo 58.4-66.1.

Potato haulms are given dried like hay to horses and cattle; the silage can only be fed to cattle. Drying or ensilage of the haulms is essential for cattle: they may be fed green to sheep at the rate of 2 kg. per head and per day, plus a small hay ration. Silaged, or dried, haulms were given to sheep at the rate of 355 gm. per head and per day, plus 280 gm. of hay.

16. — Residues from Starch and Fecule Factories (1).

Residues from starch factories. — These make a good stock feed containing all the nutritive principles of grain with the exception of starch, gluten and the soluble substances removed by washing.

In the modern method of making starch by the working up of flour, the water removes the starch and leaves the gluten which in the old process was destroyed by putrefaction. It is the residue of this new method after removal of the gluten, starch and soluble matters in the water, that constitutes the stock feed.

Part of the water is removed from the residue by centrifugation, then the mass is air-dried, so that it will keep, and made into cakes or meal. The residue from wheat grain contains: water 14 % — protein 14 % — fat 1.10 % — carbohydrates 68 %.

From 100 kg. of maize can be obtained: 50 kg. starch and 25 to 30 kg. of a residue with the following percentage composition: protein 10 — fat 6.5 — carbohydrates 15.

These residues are fed to stock mixed with hay or a chopped straw, chaff etc.

Pulps from fecule factories. — These are a mixture of fibre, fecule and small quantities of albuminoid substances. They are regarded as a supplementary food for oxen that are being fattened and for dairy cows; they are given together with oil-cakes.

The pulps must be fed fresh as soon as they are obtained, as they undergo alterations rendering them injurious to animals. If, however, it is necessary to conserve them, half their water is pressed out, and they are then made into silage, or they can be dried and ground. The percentage composition of the fresh pulp (2 analyses) was: water 86 — protein 0.7-0.9 — fat 0.1 — N-free extract 11.0-11.2 — fibre 1.8-1.4 — ash 0.4 — The air-dried pulp contains: water 14 % — protein 15 % — fat 1.1 % — N-free extracts 6.8 %.

(1) Cf.: 1) FORMENTI, op. cit. — 2) FRITSCH, op. cit. — 3) RAZOUS, op. cit. — 4) *Landw. Jahrb.*, Vol. 44, Part 5, Berlin, 1913. — 5) *Landw. Tierzucht*, Year 18, No. 21, Hanover, 1914.

When this pulp is silaged, it is arranged in alternate layers with beet slices, oil-cakes etc. As soon as fermentation sets up in the mass, the latter is vigorously mixed with a fork, after which it is suitable for stock, not excepting sheep.

It is also recommended to cook these residues in caldrons on the fire or with a steam jacket.

The amounts of pulp that can be added to the daily ration of hay, straw, oil-cake etc., are : for dairy cows 15-25 kg. — for work-oxen 12-15 kg — for fattening steers of 500 kg. weight 20-25 kg. — for sheep per 100 kg. live weight : 2-2.5 kg. — for horses 2.5-3.5 kg.

The dried pulp keeps a long time ; its percentage composition is as follows : water 18.25 — protein 4.21 — fat 0.31 — carbohydrates 66.23 — fibre 11.68 — ash 6.05. The corresponding food value obtained by multiplying the protein by 3, the fat by 2 and the fibre by 0.5, and then adding to the sum the value of the carbohydrates, is 85.13 %.

Washing waters (residual water, water containing gluten) are fairly rich in fertilising elements, and the deposit they make when at rest is used for a manure. In starch-making, these waters are freed from the fats which are mixed with bran, the liquid being expressed by means of a filter-press, and the resulting mass is dried. It forms a cake with the following average composition : water 12.2 % — ligneous matter 6.9 % — fat 7.9 % — carbohydrates 51.25 % — nitrogenous substances 14.25 % — salts 7.25 %.

The pomace induces greater thirst than the raw materials from which they are derived ; this is chiefly due to its higher potassic salts content. No salt must therefore be added to it. This pomace ought to be given warm, as it is then more digestible, but its availability is always considerable.

A stock-feed known in Germany as " Reiskleberfutter " is prepared from the gluten left as a residue from the manufacture of rice-starch. It contains in addition to this gluten, some forage rice flour, and has the following percentage composition: dry matter 92.30 — crude protein 36.94 — albuminoids 31.25 — fat 11.86 — N-free extracts 30.87 — fibre 1.32 — ash 5.31.

An experiment has been made in feeding dairy cows on this residue at the rate of 3 kg. per head and per day for the first period and of 5 kg. for the second. Its effects showed it to have the same food value as a mixture of peanut cake, beet slices and wheat bran.

17. — Rice Bran and Husks (1).

Rice bran (known in Italy as " pula vergine ") is a residue of the hulling and polishing of the grain. It includes the meal from the exterior of the mesocarp, the embryo and part of the external starch

(1) Cf. 1) MERCARELLI, B. in *Il giornale di Risicoltura*, Year V, No. 12, Vercelli, 1915. — 2) GIULIANI, R., in *Annali dell'Istituto Agrario Dr. A. Ponti*, Vol. 13, Milan, 1915-1916. — 3) GARELLI, F., in *Annali della R. Acc. di Agric. di Torino*, Vol. LX. Turin, 1917. — 4) GIULIANI, R., in *Minerva Agraria*, Year IX, Nos. 9-10. Milan, 1917. — 5) PIROCCHI, A., in *La Clinica Veterinaria*, Year XXX, Nos. 14-15. Milan, 1917.

layers. This bran is easily digested, rich in nitrogenous substances and in fats (of which it contains more than oats), bulky and soon turns acid. Its quality can be determined by the estimation of its acidity.

Prof. N. Novelli advises rice bran being pressed and made into cakes to enable it to be kept longer. In any case, it must be stored in a dry place and often turned over.

Rice bran mixed with ground rice husks is apt to produce a cough. It has no bad effect upon the milk and may be used to replace wheat bran, 0.765 to 0.860 kg. being substituted for 1 kg. of the latter. Owing to its price, which is generally lower than that of wheat bran, cakes etc., rice bran is a very economical feed for cows and draught horses.

The bran without any addition of husks represents 7 to 8 % of the paddy, or unpolished rice, but the addition of the husks brings up the amount to 10 %. At least 50,000 m. tons of rice bran containing 750 tons of oil are annually produced in Italy. When the bran is freed from fat, it keeps better and is more suited for feeding stock. By subjecting damp, hot rice bran to a pressure of 300 atmospheres at ordinary temperature, Prof. Garelli obtained 6.5 % of crude liquid oil with a specific gravity of 0.912 and a colour varying between greenish-yellow and brownish-yellow. In appearance, rice bran cake much resembles sesame cake. Rice bran contains 16.7 ‰ crude protein and 17.1 ‰ fat, while the cake made from it contains 20 ‰ and 10.15 ‰ of these substances respectively.

According to Prof. Garelli, it would be possible to obtain by pressure from 2000 to 3000 m. tons of excellent oil, and still more if solvents were employed. This oil is used in making soap, fatty acids and glycerine.

The results of an analysis given by B. Mercarelli show the percentage composition of rice bran to be as follows: water 13.1 — ash 7.4 — crude protein 12.5 — crude fat 15.4 — fibre 10.2 — N-free extracts 45.5.

Another analysis given by Prof. R. Giuliani is somewhat different: water 15.6 — crude protein 11.55 — crude fat 13.6 — fibre 9 — N-free extracts 40.1 — ash 10.5 — digestible protein 8.9. As regards food value, 0.931 kg. rice bran is equal to 1 kg. of oats.

The rations of rice bran fed by Giuliani to 10 Italian cavalry-horses for 66 days (5 periods of 12 days) in increasing amounts were 1-1.5 — 2-2.5 — 3 kg. with decreasing rations of oats of 3.2-2.7 — 2.2 — 1.7 — 1.3 kg. and constant amounts of 3.5 kg. hay and 1.2 kg. straw.

These horses readily ate the rice bran made into a mash with oats in equal weights; this bran can replace as much as ⅓ of the oat ration without the horses thereby losing any of their weight or energy.

As regards cattle, we may mention the experiments carried out by Prof. A. Pirocchi, at the request of the Commandant of the Milan Army Corps, at the "Istituto Zootecnico della Scuola Superiore di Agricoltura" of Milan, with 20 work-oxen. The rice bran used contained 24 % of nitrogenous matter + fat, and had been completely freed from the awns and chaff which in other rice brans are liable to cause coughs. 1 kg. of this rice bran was substituted for 2.035 kg. of hay.

The animals employed in the experiment ate the bran readily and it produced no ill effects on their health or working capacity, but slightly increased their total live-weight.

In conclusion, rice bran is residue that can be recommended from every point of view.

As already mentioned, it is sometimes adulterated with *rice husks*.

According to 3 analyses made by KLING (1) *rice husks* have the following average percentage composition :

water 9.4 — crude protein 3.3 — crude fat 0.5 — N-free extra 32.4 — crude fibre 38.2 — mineral substance 16.0 — According to KELLNER, they only contain 0.1 % digestible albumin, and their starch value is 2.5 %.

LEHMANN'S experiments have shown that ruminants digested 16 % of the organic matter — 10 % of the crude protein — 67 % of the fat — 35 % ot the N-free extracts — 1 % of the crude fibre.

Thus it must be conceded that the food value of rice husks is very low as a ration for cattle, and that they are injurious to swine.

18. — Brans and Oil Cakes.

The above residues are grouped under the same head in spite of their different origin, since it is merely intended to recall their existence.

These products are offered in large quantities, their market prices are constantly quoted and statistics are readily available. They have also long been employed for feeding stock, so that for all these reasons they have no special claim on treatment in this Monograph.

19. — Secondary Kinds of Cakes (2).

It appears advisable, however, to make an exception to the above-stated principle, in the case of certain cakes which are not distinguished for their quality, or quantity, and thus take a secondary places as compared with the principal cakes made from : linseed — cotton — maize — sesame — colza — rape — peanut — copra — palm-oil — poppy — soja etc.

Of the secondary cakes which are only used locally, and to a limited extent on account of the small quantities made, the following may be mentioned :

(1) Cf. KLING, Dr. M., op. cit., p. 40.

(2) Cf. : 1) KELLNER, op. cit. — 2) POTT, E., op. cit., Vol. III. — 3) KLING, Dr. MAX, op. cit. — 4) BUSSARD, L. and FRON, G. Tourteaux de Graines oléagineuses. Ch. Amat, Paris, 1905.

Sunflower cake (fig. 53). — This has a certain importance where sunflowers are cultivated on a large scale, as is especially the case in Russia, in which country the areas under cultivation and the crops produced from 1914 to 1916 were as follows (1):

	Russia in Europe (*)		Russia in Asia	
	Areas	Yield	Areas	Yield
	acres	*metric tons*	*acres*	*metric tons*
1914	2,409,871	787,832	—	10,456
1915	2,156,970	740,987	48,419	11,801
1916	1,814,734	—	42,715	—

(*) For 1914 and 1915, without Poland; for 1916 without Poland and North Caucasus.

The chief sunflower-growing centres in Russia, are Kouban, the provinces of Voronèje, Saratov and Tombov, and the region of the Don.

According to WOLFF, sunflower-cake has the following percentage composition: water 10.8 — ash 6.7 — crude nutritive elements: albuminoids 32.8; fibre 13.5; N-free extracts 27.1; fat 9.1 — digestible nutritive elements: albuminoids 27.9; N-free extracts 25.1; fat 8.1 — Nutritive ratio 1 : 1.6.

Sunflower cake, like linseed-cake, contains mucilage which gives it dietetic properties, but it also contains narcotic substances.

KELLNER advises sunflower cake for dairy cows at the rate of 2 to 2.5 kg. per head per day. It is also good for oxen and sheep that are being fattened, and can be eaten with advantage by horses, though it does not suit pigs as it fails to make firm fat.

There are two kinds of sunflower cake, one made from whole seeds, and the other from decorticated seeds. The latter is much in request in North Europe as a feed for dairy cows. In Denmark, it has been found that as compared with an equal weight of cereals, sunflower cake increases the yield of butter and milk and improves the quality of both products.

FIG. 53. — Sunflower.
From BRUTTINI A., op. cit.

(1) Cf. INTERNATIONAL INSTITUTE OF AGRICULTURE, Oleaginous Products and Vegetable Oils, pp. 84-85. Rome, 1923.

These cakes, which are difficult to grind, keep well for a long time.

In addition to sunflower-cake properly so-called, there are also "sunflower residues" composed of the integuments with a varying admixture of whole seeds. The analysis of this residue according to KLING is as follows: water 8.9 % — crude protein 18.4 % — crude fat 3.1 % — N-free extracts 25.7 % — crude fibre 39.4 % — ash 4.5 %.

Hemp Cake. — When in good condition, and free from foreign substances, hemp-cake can be fed to adult animals especially to draught-horses, but KELLNER advises the quantity being always limited to 1.5 kg. per head and per day. Oxen and sheep that are being fattened may be given 2.5 and 0.5 kg. respectively.

In the case of milch cows the amount must be limited to half a kg. per day, as hemp-cake is hard to digest, rather heating and may even cause abortion.

According to WOLFF, hemp-cake contains: water 11.9 % — ash 7.8 % — crude nutritive elements: albuminoids 29.8 %; fibre 24.7 %; N-free extract 17.3 %; fat 8.5 % — digestible nutritive substances: albuminoids 20.9 %; N-free extracts 16.4 %; fat 7.2 % — nutritive ratio 1 : 1.6. Hemp-cake makes an excellent fish-bait and a good food for fish in ponds, fish preserves etc. It keeps badly however especially if it is not salted and is very dry. It can be used as a fertiliser.

Camelina cake. — Camelina (*Myagrum sativum* L.) is a relatively little-grown Crucifera of which the seeds supply oil for illumination. KELLNER states that the plant forms a somewhat insipid stock feed with a smell resembling that of onions and mustard. It imparts a disagreeable taste to milk, butter and meat, and may even cause abortion, therefore it is regarded as a feed of little value, if not dangerous, and should always be used very sparingly.

According to WOLFF, its percentage composition is as follows: water 11.8 — ash 6.9 — crude nutritive substances: albuminoids 33.1; fibre 11.6; N-free extracts 27.4; fat 9.2 — digestible substances: albuminoid 26.5; N-free extracts 26.6; fat 8.3 — nutritive ratio 1 : 1.4.

Beech-mast cake. — Beech nuts, or mast, can be fed hulled and ground to adult swine and cattle either dry or as a mash but should never be given to horses, as serious and even fatal symptoms may result. An oil is extracted from these seeds which is used in the mountains both for illumination and for cooking. (See p. 340).

DEHÉRAIN gives the respective percentage composition of whole and of decorticated beechnuts as follows: nitrogen 3.85-5.94 — phosphoric acid 1.05 — potash 0.72 — oil 4.2-7.5.

A beech-nut cake highly recommended for cattle has been made in Germany. Its starch value is 40 % and its percentage composition, according to 2 samples, is as follows: water 16.35-10.07 — crude protein 18.50-22.2 — fat 4.40-6.90 — N-free extracts 29.90-34.30 — fibre 17.70-21.5 — ash 11.20-4.40. Whole beechnuts are poisonous (POTT) but the hulled seeds can be fed to stock at the rate of 2 kg. per 500 kg. of live-weight. When cooked, they make a good poultry-feed.

The injurious substance present in beech-mast is probably an alkaloid produced when the seeds begin to decompose on the damp earth ; it is especially toxic to horses, but appears to have little effect upon cattle and swine, provided the amount fed is within the limits prescribed above. It is best to cook the mast before feeding it ; care must be taken to throw away the water in which the nuts are boiled. Sheep and goats refuse beech mast cake made from undecorticated nuts, but poultry eat it readily.

The fat and butter of animals fed on this cake is a little soft, but this can be remedied by supplementing the ration with a small amount of bean-flour, peas, or soja.

Madia cake. — This is made by pressing the seeds of the Crucifera, *Madia sativa* Mol. The oil is used in soap-making. The cake appears to contain an injurious principle (a weak narcotic) ; only sheep that are being fattened can eat it and they in small quantities only (KELLNER). POTT limits the amount to 2 kg. per 1000 kg. of live weight.

WOLFF gives the following as the percentage composition of this cake : water 11.2 — ash 6.7 — Crude nutritive substances : albuminoids 31.6 ; fibre 25.7 ; N-free extracts 9.8 ; fat 15 — Digestible nutritive substances : albuminoids 22.1 ; N-free extracts 9.4 ; fat 12 — nutritive ratio 1 : 1.8.

Walnut and Hazelnut cakes. — Walnut cakes contain certain bitter substances rendering them unsuited to dairy-cows, but they are a good feed for work-oxen and steers that are being fattened, and also for swine and poultry. These cakes quickly turn rancid and in this condition should only be used as a fertiliser as they impart a disagreeable taste to animals fed on them.

Contrary to the generally received opinion, BUSSARD and FRON maintain that walnut cakes promote milk production.

According to WOLFF, their percentage composition is as follows : water 13.7 — ash 5 — crude nutritive substances : albuminoids 34.6 ; fibre 6.4 ; N-free extract 27.8 ; fat 12.5 — Digestible nutritive substances : albuminoids 31.1 ; N-free extracts 28.2 ; fat 11.2 — nutritive ratio 1 : 1.8.

One analysis quoted by KLING gives the following percentage composition : water 9.5 — crude protein 9.5 — crude fat 9 — N-free extract 46.3 — crude fibre 23.7 — ash 2.

A similar cake is made from the nuts of the hazel (*Corylus avellana* L.) : It has the following percentage composition : dry matter 92.9 — nitrogenous matter 17.4 — crude fat 62.6 — N-free extracts 7.2 — crude fibre 3.2 — ash 2.5. According to POTT, however, the number of analyses made is not sufficient.

Hazel-nut cake is superior to walnut-cake in so far that it contains no bitter substances but stock do not eat it readily unless mixed with walnut-cake ; it is rarely put on the market. Hazel-nut cake first pressed hot and then cold still contains 8-14 % of oil: PIROTTA and COSTANTINO (1) recommend it as a stock feed and when ground also for human food.

These authors found the percentage composition of dry hazelnut cake to be as follows: total nitrogen 8.3 — protein substances 51.8 — N-free extract 30.5 — invert sugar 15.4 – fibre 10.3 — ash 7.4.

Tobacco cake. — G. PARIS (2) has conducted some experiments with the oil and cake made from the seeds of Eastern cigarette tobacco (Xanthi-Yaka, Herzegovina etc.). One plant of this tobacco produces 2.5 gm. of seed as against 40 gm. obtained from Brazilian tobacco.

Italy could produce as much as 200 to 250 metric tons of tobacco seed, a residue which is at present entirely unused and wasted.

The percentage composition of tobacco cake is: water 9.17 — crude protein 21.87 — crude fat 37.68 — starch and sugar 6.05 — pentosans 2.90 — bre 7.15 — crude ash 3.84. The ash contains: 1.97 % phosphoric acid — 22.12 % sulphuric acid — 3.45 % soda — 28.05 % potash — 9.54 lime — 14.63 magnesium.

The percentage composition of a tobacco cake made at Cerignola was: water 11.83 — crude protein 28.63 — crude fat 1.64 — N-free extracts 31.41 — fibre 19.90 — ash 6.59. No nicotine was present. Digestibility coefficients: protein 65 — fat 80 — N-free extracts 75 — fibre 45 — nutritive ratio 1 : 1.8.

From 250 metric tons of seed 80 tons of oil can be obtained and between 160 and 170 tons of cake for a stock-feed, or fertiliser.

Cherry and Plum-stone cake. — Experiments have been made in the United States to determine how refuse cherry-stones can best be used. When the oil has been extracted (see p. 336), the residue makes a good feed for stock, its percentage composition when dry being: protein 30.87 — ether extract 13.10 — N-free extracts 42.13 — fibre 8.90 — ash 3.94.

A cherry-stone cake contained: crude protein 8.3 % — crude fat 6 % — N-free extracts 25 % — crude fibre 46 %. During the war, the stones of cherries and of other fruits were used very successfully in Germany, for making cakes for a stock-feed.

The following is the percentage composition of a cake made from *plum-stones*: crude protein 4.1 — crude fat 4.5 — N-free extracts 20.5 — crude fibre 57.0.

Cake of Pumpkin seeds (*Cucurbita* sp.). — In South Hungary and other countries where pumpkins are largely grown, an oil is extracted from the seeds and the residue makes a digestible cake with a good flavour, though it easily turns rancid if any considerable amount of oil has been allowed to remain in it. The cake made of undecorticated seeds is better liked by stock than that made from decorticated seeds.

(1) R. PIROTTA and A. COSTANTINO, Utilizzazione di piante alimentari selvatiche. *R. Acc. Lincei. Com. Scientif. per l'Alim.* Rome, 1919.

(2) Cf. *Bollettino tecnico del R. Istituto Scientifico-Sperimentale del Tabacco,* Year XVII, No. 1, Scafati, 1920.

The following table gives the percentage composition of several secondary cakes.

Cakes	Water	Crude protein	Crude fat	N-free extract	Crude fibre	Ash
Sinapis arvensis	9.5	30.5	5.5	30.5	13.8	10.2
Guizotia oleifera	8.8	28.5	4.6	26.1	17.5	14.5
Lime	12.4	12.9	7.9	31.4	28.4	7.0
Lemon-pips	—	22.1	10.8	27.9	—	—
Eriondendron anfractuosum (Kapok)	9.5	30.8	5.3	22.1	24.2	8.1

Amongst other secondary cakes may be mentioned: *olive residue cake* — *grape-seed cake* (see p. 178) and those made from *cumin* (*Cominum Cyminum*), *caraways* (*Carum Carvi*), fennel, celery, coriander, anise, mustard, and castor-oil seeds and from the seeds of *Lepidium sativum* L., *Thlaspi arvense* L., *Arabis sagittata* D. C., Currant, *Cornus sanguinea* L. (bitter and astringent), and *Sambucus nigra* L. (emetic and carthartic). Castor-oil cake is poisonous, even in small quantities. KELLNER says that after the poison has been removed or destroyed by boiling or steaming, it can be fed to stock but as a rule, agriculturists prefer using this cake as a fertiliser.

Rice bran cake. — Rice bran already mentioned (No. 17), when freed from fat by means of pressure and solvents, makes a good cake for stock and still contains 8-9 % of fat, and 17-18 % of crude protein. When treated with solvents it is almost free of fat and contains 50-55 % of starch and keeps better (1).

A cake is also made from sweet almonds and from bitter almonds respectively. The former is good for cows, but the latter is poisonous owing to the presence of amygdalin and emulsin, substances producing prussic acid. Both these cakes are employed in the manufacture of the almond flour required in perfumery, consequently their cost would in any case prevent their being used to a large extent as stock-feeds.

The above remarks apply also to *apricot-cake*.

20. — Olive Oil Residues.

Although olive oil residues are often compared to cakes made from oleaginous seeds, it is best to treat them separately, all the more since they are the by-product of fruits, not of seeds, and are handled generally in broken pieces rather than in the form of more or less thick cakes.

(1) Cf. *Il Giorn. di Risicultura*, Year VII, Nos. 11-12, 13, 15-16, Vercelli, 1917, and Year IX, No. 9, Vercelli, 1919.

According to P. CUPPARI 153 hectolitres of olives weighing 12,660 kg produce about 77 hectolitres of residue weighing 6,000 kg. for subsequent washing in the separating mill. After washing, these 77 hectolitres give about half this quantity of stones and 9.5 hectolitres of skins from which the oil is extracted. The rest is a sediment that makes a good fertiliser.

Prof. G. BRIGANTI in a valuable article (1) says that olive residues when freed from the stones and reduced to flour have been repeatedly found to form a good stock-feed especially suited to cattle. On the other hand, the residue containing the stones may produce serious digestive trouble and should not be fed to cattle, or even to swine, although they are less susceptible. The stones are removed by means of special apparatus like the BRACCI, ROMEI, TOCCHI and ROSSINI stoners, or a cereal winnower of which the sieves are adapted to this purpose.

Two workers can obtain daily 1000 to 1200 kg. of skins.

Prof. F. BRACCI estimated that 60 to 65 parts out of 100 of this residue can be used, the rest is made up of stones. He gives the percentage composition of the residue freed of stones as follows: fat 11.63 to 18 — crude protein 11.50 to 11.68 — N-free extracts 22.41 to 41.38 — crude fibre 19.16 to 24.12 — Digestible albuminoids 5.77. These figures, especially those referring to the fats, vary with the kind of olives, the method of treatment etc.

As regards the *rations* fed, Commander COLOSSO d'Ugento (Lecce) gave the following:

Horses: morning and evening, oats and straw; midday, a mixture of $\frac{1}{3}$ olive residues and $\frac{2}{3}$ flour of leguminosae instead of bran.

Cattle and swine: in addition to hay and straw, a mixture of $\frac{2}{3}$ olive-residue flour and $\frac{1}{3}$ flour of leguminosae.

Dogs: olive residues up to 5 % of the ration.

Prof. BRACCI recommends: Oxen and cows 2-4 kg. — Calves 1-2 kg. — Fattening swine 0.8-1.5 kg. — Sheep and goats 0.2-0.3kg. It is better to give the olive residues as mash or wash mixed with other substances that contain little fat and much nitrogen.

The fresh residues must not be allowed to turn rancid or they may become injurious.

Residues that have been exhausted with carbon disulphide, dried and winnowed to separate the stones from the pulp and skins, can also be used as a cattle-feed, if mixed with barley, bran etc.

The percentage composition of olive residues as found by analysis at the Agricultural Experimental Station of Modena was: digestible fat 3.80 — digestible albuminoids 7.20 — N-free extracts and digestible fibre 39.10 — nutritive ratio 1 : 6.7 — commercial unit 65,44. The residues are fed at the rate of: 1 kg. per head and per day to cattle and swine — 250 gm. to sheep and goats.

(1) Cf. G. BRIGANTI, L'utilizzazione dei cascami dell'olivicultura nell'alimentazione del bestiame. *Bollettino della Società degli Agricoltori Italiani*, Year XVII, No. 16-17, 1912.

During the War, olive oil residues were successfully used for feeding pigs. Prof. CUGNONI (1) made an interesting study in this connection. The crude residue may contain 50 % skins and 50 % stones, the skins are separated by winnowing and given to stock.

This author made experiments in feeding pigs on fresh olive residues and on those that had been exhausted by the usual solvents. The respective percentages were as follows:

	Fresh olive residues	Exhausted olive residues
Dry substances	89.98 %	85.71 %
Digestible nitrogenous substances	5.36	5.69
N-free extracts and fibre	39.95	35.38
Fat	9.98	1.70

Olive residues could be substituted for maize flour: 117 kg. of the latter was replaced by 148 kg. of fresh winnowed residues (skins) and by 165 kg. of exhausted residues (skins). They caused no inconvenience to the animals employed in the experiment, and the coarseness of hair attributed by the peasants of Umbria to this diet was less observable with the exhausted residue than with the fresh residues.

Subsequently (in 1917), Prof. CUGNONI conducted other feeding experiments on 3 cows (2) which were given fresh olive residues for 3 periods each lasting 30 days (the first and third period serving as a control; the ration consisted of hay + maize-meal + bran + beets; in the second period, the bran was replaced by an amount of olive residue of equal food value with the addition of 15 % of peanut cake, that is to say, the mash contained instead of 2 kg. of bran, 1.8 kg. fresh residue free from stones in addition to the peanut cake.

From these experiments Prof. CUGNONI concludes that olive residues should be very fresh, thoroughly freed by winnow from all stones and supplemented by a concentrate. Under these conditions, they have the same influence as bran on the production of milk, fat and live-weight, while they are more available than bran. Olive-oil residues are thus easily fed and are most suited to all stock, especially dairy cows and swine.

To give some idea of the total quantity of olive-oil residue that could be turned to account in Europe, the following data of olive-oil

(1) Cf. *Il moderno Zooiatro*, Year IV, Bologna, 1915.
(2) *L'Industria lattiera e zootecnica*, Years XVII and XVIII, Reggio Emilia, 1919-1920.

production may be quoted (1). By the help of a coefficient (2-2.5) the corresponding amount of fresh residue obtained has been determined; in order, however, to allow ample margin for cost of labour, transport, preservation etc., this coefficient may be reduced to 150 kg. of fresh residue per 100 kg. oil.

	Metric tons oil
Spain	252,251 (1909–1918)
Italy	174,259 (id.)
Greece	98,775 (1914–1918)
Portugal	28,225 (id.)
Austria	3,669 (1909–1915)
Tunisia	30,083 (id.)
Algeria	26,147 (id.)
Total	**613,409** metric tons
Corresponding fresh olive-oil residue	**920,114** » »

Assuming that equal amount of stones and skins respectively are available whether for the extraction of oil (by separating-mill or by solvents) or for stock feed, the following figures result for the production of olives in Europe:

skins . . . . 460,057 metric tons
stones . . . . 460,057 »

The extraction of oil from the residues, especially by means of solvents, has however been largely developed, and thus the skins freed from the stones are only available in part for feeding stock although the exhausted skins can also be employed for this purpose, as has been seen.

Since on the other hand, at least 12 % of oil (putting it at a very low average) can be extracted from the skins, if we take from the total quantity of skins produced in Europe (460,057 m. tons) the amount of oil that can be extracted from it, 55,206 m. tons, a mass of exhausted skins remain (404,850 m. tons) which can well be fed to live-stock.

It is easy to calculate the enormous quantity of nutritive principles contained by this residue which could be turned to better and more extensive account than is done at present. To obtain this estimate we take as a basis the figures resulting from the analyses of the fresh and the exhausted olive-skins above mentioned which give the following annual averages:

(1) INTERNATIONAL INSTITUTE OF AGRICULTURE, *Yearbook of Agricultural Statistics*, 1917-1918. Rome, 1920, p. 111.

	Fresh residue	Exhausted residue
	m. tons	m. tons
Dry matter	413.959	346.997
Digestible nitrogenous substances	24.659	23.035
N-free extracts and fibre	165.390	143.236
Fat	45.913	6.882

As was said above, Prof. CUGNONI has been able, in feeding pigs, to replace 117 kg. of maize by 148 kg. of fresh olive-oil residue and 165 kg. of the exhausted residue. According to these figure, the amounts of maize flour equivalent to the above given masses of residue would be as follows :

Fresh olive oil residue 460.057 m. tons = Maize flour 363.673 m. tons
Exhausted olive oil residue 404.850 m. tons = Maize flour 286.374 m. tons

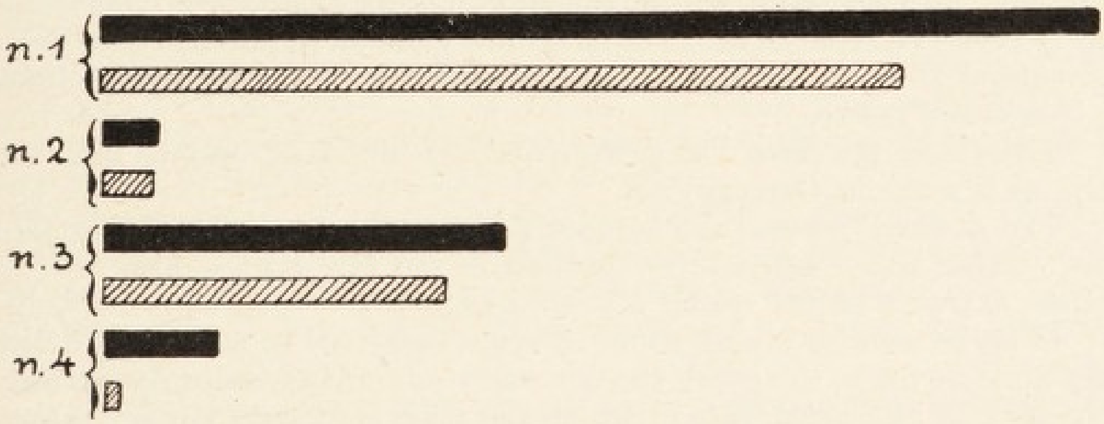


FIG. 54. — Diagram showing the average world production of olive-oil residue (figures given above).

Black = fresh residue — *Hatched* = exhausted residue. — No. 1 dry matter ; No. 2 digestible nitrogenous substances ; No. 3 N-free extracts and fibre ; No. 4 Fat.

21. — Residues of Sugar Refineries (1).

Beet pulp or slices — These are the completely exhausted residues of the beet, sometimes called diffusion pulp. The pressed slices have lost a good deal (15 to 50 %) of their water, and are more suited for a stock-feed. When fresh, their average percentage composition is

(1) Cf. : 1) KELLNER, O., op. cit. — 2) J. FRITSCH, op. cit. — 3) P. RAZOUS, op. cit. — 4) BARLOW, H., *The Agric. Gazette of New South Wales*, Vol. XXV, p. 12, Sydney, 1914. — 5) KOCH, *Fuhlings Landw. Zeit.*, Year 65, Nos. 5-6, Stuttgart, 1916. — 6) C. O. TOWNSEND, By-Products of the Sugar-Beet and Their Uses. U. S. Dep. of Agric. Repr. from Yearbook, 1908. Washington, 1909. — 7) R. C. CALLOWAY, Feeding Black strap Molasses to Young Calves. *Louisiana St. Univ. Agric. Exp. Stat., Bull.* No. 180, 1921.

as follows: water 90-92 — protein 0.9-0.6 — fat 0.2-0.1. — N-free extract 6-7 (MUNERATI).

After pressure while still fresh (20 % of the weight of the beetroot) they contain, according to CORENWINDER: water 71.42 % — sugar 3.62 % — fat 0.628 % — fibre 10.345 % — nitrogenous substances 2.381 % (nitrogen 0.381 %) — pectose and other investing substances 9.434 % — mineral substances 2.172 % (1).

For an ox weighing 600 kg., the maximum ration, according to WOLFF, is 32 kg. of crude slices (95 % water), whereas up to 47 kg. of pressed slices (85 % water) can be fed, corresponding to 53 kg. of unpressed slices; this gives an increased consumption of more than 60 % due to pressure. Silaged pulp can be given at the rate of 15-20 kg. a day to calves 4-6 months old, of 50 kg. to cows, and of 70 kg. (in two rations) to oxen that are being fattened.

The above-mentioned pulp is used just as it leaves the diffusor, and its nutritive value is very low, for it only contains about 13 % of nutritive substances. Hence in order to obtain 130 kg. of useful matter, 1 ton of pulp containing 870 kg. of water must be used. Such pulp is troublesome to transport, further, the growers are obliged to remove all they want within the short period of about 2 ½ months and to preserve them in silos ready for daily use as required. The pulp loses about 40 % in the silo. After 7-8 months, it weighs 980 to 1050 kg. per cubic metre.

Therefore, provided the price of fuel is low, it is best to dry the pulp, as is done in Germany.

The average percentage composition of the dried pulp is as follows: water 12 — ash 6.5 — protein 8 — fat 1.2 — fibre 18 — N-free extracts 55 (of which 5.7 % is sugar).

It keeps well for a long time. Before being fed to stock, the dried pulp must be made to absorb the necessary amount of water by putting it to soak in the great vats in which the mass is mixed up 2 or 3 times a day: 100 kg. of dried pulp should be put into a vat of 5.5 hectolitres capacity. After 24 hours, it may be given to the animals. One hectolitre of dried pulp weighs from 27 to 28 kg. The daily ration for a work-ox is 4 to 6.5 kg. with the addition of hay, straw and oil-cake. A cow is given 4 to 5 kg. without the addition of hay, straw or cake or 3 kg. if these are added, or else may be fed 30 to 40 kg. of moist pulp. Sheep receive 0.6 kg. per head without any addition of hay etc., and horses are given 0.4 to 0.5 kg. daily.

Molasses. — This is the residue of the beet-juice after the crystallisable sugar has been removed, but it still contains a quantity of sugar that cannot be separated from the other substances with which it is mixed.

Molasses represent 2 % of the weight of the beets and contain 40 to 45 % sugar (which forms 63 to 71 % of the dry matter), 10 to 12 % mineral substances and 5 % digestible albumin. The mineral sub-

(1) Cf. P. HORSIN-DÉON, Traité de la fabrication du sucre de betterave. L. Geisler, Paris, 1911.

stances are composed in a large extent of potassic salts, but a little lime and a very small amount of phosphoric acid are present.

According to WOLFF, their average percentage composition is as follows: water 17.2 — ash 8.26 — nitrogen 1.28 — phosphoric acid 0.05 — sulphuric acid 0.16 — potash 5.87 — lime 0.41 — magnesium 0.03 — soda 1.01 — silica 0.03 — chlorine 0.82.

Beetroot molasses is a viscous liquid or even a paste, of a dark colour and possessing a characteristic odour. Its water content varies greatly: it may range between 15.5 and 32 %.

Molasses is much used in alcohol manufacture, but also serves as a stock-feed. It can be given alone, when sufficiently diluted, but is best used for sweetening other foods, rendering them very acceptable to animals and obviating any danger of colic, or other disturbances of the digestive system. The excipients employed should be waste products or residues suitable for feeding stock and not more or less inert substances such as saw-dust, peat, tanning refuse, walnut flour, and maize stems etc. The best excipients are: brewers' grains, forage cakes, maize germs, brans, and cereal offals. These should be mixed with about 50 % molasses. Straw is also a good excipient.

With the exception of straw mixed with molasses, all other feeds containing molasses must be regarded as concentrates to be fed in the following quantities per head and per day: horses of 500 kg. 1.4 to 2.4 kg. — adult oxen 2.4 to 2.5 kg. — sheep and swine 0.500 kg. As regards straw mixed with molasses, 6 to 7 kg. can be fed to cattle, 0.5 to 0.7 to sheep and 1 to 2 kg. to pigs.

Sugar-cane molasses can also be used as a stock-feed. BARLOW has made a food composed of 80 % molasses and 20 % sugar-cane pith of which the percentage composition was: water 18.3 — ash 8.8 — fibre 9.3 — fat 0.4 — albuminoids 8.4 — sugar and digestible fibre 54.8.

Dairy cows given 3.17 kg. per head and per day yielded much milk of good quality but the economic results were not satisfactory.

In order to complete the statistics given for the root-collars and leaves of beets (see p. 111), we will now give the amount of pulp, molasses and their percentage of nutritive substances calculated from the average world production of beet.

The pulp is estimated from the pressed pulps, which according to CORENWINDER, is 20 % of the weight of beets used. The nutritive substances are reckoned on the basis of the data of the analysis made by CORENWINDER.

TABLE I. — *Amounts of crude nutritive substances present in the pressed pulp of the sugar-beets produced in the world during the period* 1909-1910 *to* 1918-1919, *taking the total production as* 47,459,510 *m. tons.*

Amount of pressed pulp	(20 %)	9,491,902	metric tons*
Sugar	(3.62 %)	343,607	» »
Fat	(0.628 %)	59,609	» »
Fibre	(10.345 %)	981,937	» »
Nitrogenous matter	(2.381 %)	226,002	» »
Nitrogen of nitrogenous matters	(0.381 %)	36,164	» »
Pectose and investing substances	(9.434 %)	895,466	» »
Mineral substances	(2.172 %)	206,164	» »

(*) The amount of pulp, or slices, dried to the extent of 5 % was 2,372,975 metric tons.

TABLE II. — *The nutritive substances and fertilising matters contained in the molasses from the world production of sugar-beets during the period* 1909-1910 *to* 1918-1919, *the amount being estimated at* 47,459,510 *m. tons.*

Molasses	(2 %)	949,190	metric tons
Sugar	(45 %)	427,135	» »
Digestible crude albumin	(5 %)	47,459	» »
Nitrogen	(1.28 %)	12,149	» »
Phosphoric anhydride	(0.05 %)	474	» »
Potash	(5.87 %)	55,717	» »

22. — Distillery residues (1).

Potato waste. — After the starch has been used for the manufacture of alcohol, all the other nutritive substances of the potato remain in the residue. The quantity of water it contains makes its transport a matter of considerable difficulty. Its percentage composition is as follows: water 94.24 — fat 0.135 — fibre 0.555 — ash 0.72 — albumen 0.99 — amides 0.34 — N-free extracts 3.02.

According to WOLFF, the percentage composition of the ash is: potash 4.24 — soda 0.73 — lime 0.49 — magnesium 0.81 — iron oxide 0.16 — phosphoric anhydride 1.846 — sulphuric acid 0.67 — silica 0.312 — chlorine 0.267.

The liquid residues are collected as they leave the distilling apparatus and are fed to dairy-cows and oxen that are being fattened.

The dried residues keep well, but owing to the present high cost of fuel, the drying process is now too expensive.

Maize residue. — This is the waste product resulting from the saccharification of maize by means of acids, or barley malt. If malt

(1) Cf.: 1) KELLNER, op. cit. — 2) J. FRITSCH, op. cit. — 3) E. POTT, op. cit., Vol. III.

is used, the residue is an excellent stock-feed, contains when it leaves the apparatus employed about 92 % water and 8 % dry matter. This fluid deteriorates very quickly and lactic and butyric acids are formed and moulds appear, so that it becomes injurious to stock.

For this reason, it should be fed immediately, unless the solid matter can be removed by decantation, pressed, and made into cake, but even under this form, the residue is difficult to keep and further has lost 40 to 50 % of the nitrogen and soluble phosphates which remain in the decanted water.

The only really satisfactory manner of preserving this maize refuse is to dry it first on great plates of iron heated by steam, and afterwards in driers with oscillating action, and then grind the dried substance to powder.

When dried in this way, all the nutritive substances present in the grain are retained except the starch which has been saccharified and transformed into alcohol. Thus desiccated, the residue can be kept indefinitely without fear of fermentation, or mould production, and forms an excellent food for all domestic animals, especially for stock that is being fattened. The average percentage composition of dried maize refuse is as follows: water 9.59 — nitrogenous substances 27.05 — fat 9.24 — N-free extracts and fibre 49.78 — ash 4.34.

The increase in nitrogenous matter which rises from 10 % in the maize grain to 27.05 % in the residue is due to the disappearance of the starch.

Animals usually eat this maize waste readily ; it is especially suitable for draught horses, and is fed dry mixed with an equal amount of oats.

A work-ox weighing 600 kg. may be given 6 kg. of hay and 6 kg. maize residue a day. The amount of the latter may be raised to 8.5 kg. and 2 kg. oil-cake added in the case of an ox that is being fattened. Maize residue is best fed as a mash. In fattening sheep, 500 gm. of maize refuse is more profitable than 1.5 kg. oats + bran + ground peas, while about 250 gm. is a good fattening ration for swine of normal size.

Maize residue that has been saccharified by means of acids is no longer fit for a stock-feed, but should be used as a fertiliser on the fields near the distillery.

The residues from other distilled cereals (wheat, rice etc.) also form a good food for stock.

Vinasse, or pomace, is the residue from the distillation of the must obtained by the fermentation of starch-containing tubers and the grain of cereals ; it also contains yeast, and its digestible portion is very rich in albuminoids. The richest of these residues is obtained from cereals, after which come potato and molasses *vinasses*. But these last owing to their high salts content are not suitable to be fed to live stock.

Must residue is always given fresh to animals. Oxen that are being fattened and dairy cows may be fed 60 litres and 40 litres a day respectively. To sheep and pigs that are being fattened only 2 to 3 litres may be given, while 10 to 15 litres daily suffice for draught-horses.

When fuel is cheap, this distillation residue can be dried (maize, rye, or even barley malt, being added when it is to be given to live-stock) 3 kg. a day may be fed to oxen and dairy cows and 0.500 kg. to sheep destined for the butcher.

Residue from Cherries. — This is the solid refuse from the distillation of "kirschwasser". It is given alone to poultry and mixed with boiled potatoes to pigs. It must not be forgotten that the stones of cherries, like those of plums, peaches, apricots etc., contain *lauro-cerasine* which when acted upon by the emulsion associated with it produces *prussic acid* in the stomachs of animals causing serious toxic symptoms that are usually fatal.

Date residues. — In North Africa, date stones (generally crushed) are fed to camels, sheep and goats. The dry residues from the distillation of fermentated dates are also used for the same purposes. According to Ch. Girard, the percentage composition with and without the dates is respectively: dry matter 52.90 — 53.32, nitrogenous matter 2.47-2.46 — fat 0.78-0.16 — sugar, starch etc., 22.25-57.74 — N-free extracts 22.80-17.17 — fibre 3.39-2.55 — mineral substances 1.21-2.24.

23. — Brewery residues (1).

Brewers' grains are the refuse germinated barley after the latter has been freed from sugar and other soluble substances by boiling in water for the purpose of obtaining beer must (2). When fresh they are used as a stock-feed, especially on farms near breweries.

Dry brewers' grains are much more suitable for feeding animals than fresh ones, as the latter are difficult to keep and cost a great deal to transport. Not more than 2 to 3 kg. per head and per day must be given to dairy cows (E. Pott). They may be fed to fattening oxen and to sheep (0.5 to 1 kg.) as well as to draught horses (1.5 to 3 kg.) swine and poultry.

Brewers' grain contain all the fibre of the barley and almost all the nitrogenous matter and insoluble mineral substances present in the latter. When fresh, their average percentage composition is: water 70.85 % — nitrogenous matter 4.7 — fat 1.7 — N-free extracts 10.5 — crude fibre 5.0 — ash 1.2. Dry brewers' grains contain on an average: dry matter 90.1 % — nitrogenous substances 21 % — fat 7.5 % — N-free extracts 41.7 % — crude fibre 15 — ash 4.8 %. The following coefficients of digestibility were obtained from experiments with sheep and oxen: dry matter 78 % — crude fat 89 % — N-free extracts 63 %.

(1) Cf.: 1) J. Fritsch, op. cit. — 2) P. Razous, op. cit. — 3) Kellner, op. cit. — 4) *The Journal of the Board of Agriculture*, Vol. XXII, No. 1. London, 1915 — 5) E. Pott, op. cit. Vol. III, p. 286 — 6) Th. Koller, op. cit. — 7) Dr. Max Kling, op. cit.

(2) There are also wheat residues but they are of much less importance than brewers' grains.

Brewers' grains are generally fed to stock mixed with hay or chopped straw. They can be kept fresh for some days if put into very clean bins. If it is necessary to keep them longer, a silo is required. Other methods of preserving these residues are : 1) drying them in the malt-kiln as soon as they leave the brewing-vat ; 2) making them into cake after centrifugation and steam-drying ; 3) mixing them with bran or different kinds of meal, making into loaves and baking in the oven.

Barley germs. — These are the barley developed embryos which are mechanically separated by the degermer from the germinated barley. This residue is very rich in nitrogen (4.5 %), sugar, potash and in phosphoric acid which represents 3 % of the weight of the barley.

E. Pott gives the average percentage composition of dried barley germs as follows : dry matter 90 % — nitrogenous matter 24.4 — crude fat 2 — N-free extracts 42.4 — crude fibre 14 — ash 7.2. From experiments made on sheep and swine by Wolff and other investigators, the digestibility coefficients were found to be : nitrogenous matter 81-75 % — crude fat 68-65 % — N-free extracts 76-85 %.

The barley germs are dried and reduced to a forage flour that is best mixed with chopped straw when fed to stock.

In calculating the ration, the same amount of barley germs is taken as of flour or cake.

Barley germs are much used in Germany as a food for horses, or dairy cows ; they may also be advantageously given to calves ; 2 litres of germs replacing 1 litre of oats. When given to cows and calves, these embryos are mixed with beet pulp, or molasses, fed at the rate of 1.5 to 2 kg. per head and per day ; 1 kg. may be given to pigs , 1.5 to 2.5 kg. to draught horses and 250 gm. per 50 kg. of live-weight to sheep. They also make a good poultry feed.

Washing residues. — During the washing of malt-barley, 1 % or even more defective seeds that float on the water can be separated out. These are collected and fed at once to stock, for being wet they would quickly decompose. If the grain is very dirty it is best to boil it first.

The *lees from the decantation* of beer in the refrigerator have also served as a stock-feed. The following are results of two analyses made respectively by Völtz and Schulze : water 8.5 and 5.9 % — crude protein 43.6 and 32.5 % — crude fat 3.9 and 4.1 % — N-free extracts 32.9 and 53.4 % — crude fibre 6.8 and 1.7 — ash 4.3 and 2.4 %.

Hop residues. — These can be used both as a fertiliser and stock-feed. As regards composition, they correspond to clover hay of average quality. Although experiments in using hops for feeding live-stock had been made previously to the war, it was only during the war that they were much employed for this purpose, both alone or mixed with beer-lees and even with other brewery refuse. When dry these hops contain 6.2 to 9.6 % water — 23 to 22.4 % protein — 37.4 to 28.5 % N-free extracts — 24.5 to 28.2 % crude fibre — 5.3 to 4.8 % ash.

KELLNER found in his experiments on sheep that the digestibility coefficient of the nutritive substances in this food with the exception of that of the crude fat was lower than the digestibility coefficient of any of the food-stuffs hitherto analysed, only 38.6 gm. protein — 2.4 gm. fat — 15.5 gm. N-free extracts and 41.1 gm. crude fibre being available.

This is due, amongst other causes, to the fact that the crude fibre contains 24 % of lignin. Further, the fat (ether extract) is not pure, but is mixed with resinous substances, and some of the protein is combined with tannic acid which hinders the action of the digestive fluid. As animals do not readily eat these hops, they will never be much employed as a stock-feed. Their digestibility is somewhat improved if they are ground and fed with other substances; they have been recommended as a useful addition to a ration of chopped straw.

We have based our calculations as to the nutritive substances obtainable from brewery residues upon the statistics furnished by various States between 1911 and 1913 (1) viz., almost up to the time when beer production became abnormal instead of taking the figures for the quinquennial period 1916-1920. This latter includes 3 years of the war and 2 years of the post-war regime, when the data available were scarce, there were no returns from Hungary and the Balkans, and the output of brewers' grains and barley embryos fell far below the pre-War figure, and was greatly inferior to the present production. An increased supply may be expected in the future, as a result of the revival of industry and a return to normal conditions in the different countries.

For the European States, Argentina, Chili, United States and Japan, and for certain other countries, the following totals are obtained by multiplying the beer production by the respective coefficients viz., 6 % for dry brewers' grains and 1 % for dry embryos:

Dried brewers' grains	1,757,188 m. tons.
Dried embryos	292,873 » »

The amount of nutritive substances obtained from the world's brewery products during the period 1911-1913, *taking as a basis* 1,757,188 *m. tons of dried brewers' grains and* 292,873 *m. tons of dried embryos.*

		In the brewer's grains	In the embryos
		m. tons	m. tons
Dry matter	(grains 90.1 : emb. 90 %)	1,583,226	263,585
Nitrogenous substances	(grains 21,0 : emb. 24.4 %)	369,009	71,461
Fat	(grains 7.5 : emb. 2.0 %)	131,789	5,875
N-free extracts . . .	(grains 41.7 : emb. 42.2 %)	732,747	124,178
Crude fibre	(grains 15,0 : emb. 14 %)	263,578	41,002

(1) Cf. INTERNATIONAL INSTITUTE OF AGRICULTURE. International Trade in Concentrated Cattle Feeding stuffs, No. 4, Rome, 1918.

24. — Yeast or Ferments (1).

During the great dearth of food products at the time of the war, experiments were conducted, not only on active beer yeast, but also on other yeasts and ferments, with a view to determining how far they were suitable for stock-feeds or for human consumption.

Dried beer yeast is used on a large scale as a concentrate in Germany, while in England, there are also factories where the dried yeast is prepared and exposed to the extent of over 3000 tons per annum. KOLLNER gives the average percentage composition of this beer-yeast as follows: water 4.3 — protein 48.5 — oil 0.5 — fibre 0.5 — ash 10.7 — soluble carbohydrates 35.5.

Experiments made in Yorkshire have proved this yeast to be a good food for cows, calves and swine, although cows do not eat it readily, probably on account of its bitter taste. Being very rich in protein, beer yeast can be mixed with other feeds such as oil-cakes etc.

Feeding experiments with *beer-yeast* were carried out during the war at the Leeds Experiment Station (England). The percentage composition of the yeast was: water 10.9 — crude albuminoids (7.7 % aitrogen) 48.3 — oil 0.5 — crude fibre 1.6 — ash 8.1 — soluble carbohydrates 30.6.

In the case of the cows, the effect was compared of an oil-cake ration of 1.36 kg. per head and per day and that of the same amount of yeast to which had been added a small quantity of molasses to correct the bitter taste. The yeast proves a little superior to the cake. With pigs yeast was fed in place of the same weight of sharps with the result that the animals increased more in live-weight, thus showing yeast to be an excellent pig-feed if given as a supplement to the ordinary ration of substances richer in starch.

In Germany, beer yeast was fed alone. and also mixed with dried brewers' grains in the proportion of 25 % yeast to 57 % grains. The mixture was dried in a special manner.

The production of beer-yeast is reckoned in Germany at about 4.3 kg. per 100 kg. of barley.

The annual output of fresh pressed yeast is estimated at 70 million kg. which corresponds to 21 million kg. of dried yeast. A very good drier is the Sesto apparatus of the " Maschinenfabrik L. Soest and Co. " at Düsseldorf-Reisholz. In 1913, this plant was used in 26 factories. The drying operation is similar to that employed for potato flakes, the pressed mass passes between 2 cylinders turning in opposite directions and heated inside with steam (2).

(1) Cf.: 1) *Die Landw. Versuchsst.*, Vol. XCII, Parts 3-4. Berlin, 1920 — 2) *Landw. Jahrbuch*, Vol. 47, Part 2. Berlin, 1914 — 3) *Köztelek*, Year 24, No. 76. Budapest 1914 — 4) *Landw, Jahrb. für Bayern*, Year 6, Nos. 11-12. Munich, 1916 — 5) KOLLER, TH., op. cit. — 6) KLING, Dr. MAX, op. cit.

(2) Cf. KOLLER, Dr. TH., op. cit., pp. 43-54.

VÖLTZ gives the average digestibility coefficient of the crude protein, in the case of different animals as follows: lambs 0.5 % — swine 90.8 % — horses 69 %. The digestibility of the N-free extract varies from 76 to 100 %.

It can be assumed that yeast generally suits all live-stock and especially pigs to which are fed according to their live-weight (15 to 90 kg.) from 150 to 600 gm. per head and per day. Milch cows receive 1-2 kg. and horses 0.5 to 1 kg. When mixed with starchy foods, yeast can be substituted for half the oats ration ; 300 gm. are fed to sheep. while it is mixed with pastes for poultry ; 300 gm. of dried yeast + 700 gm. potato flakes are equal to 1 kg. of oats.

HONCAMP has carried out feeding experiments on sheep and goats using for the purpose dried ferments obtained by various processes, and undried ferments, the so-called deposits of the lees. Sheep digest both kinds of yeast equally well. From 72.9 to 93 % of the protein was digested. Swine utilise the protein as thoroughly as sheep, and make better use of the N-free extracts.

In another experiment on sheep, the value of the ferment proved equal to that of soya-flour. As a pig-feed, however, yeast is inferior to fish-meal.

From VÖLTZ's experiments in Germany, it appears that yeast increases the fat content of cow's milk but to a less extent than palm-oil cake.

In Hungary, SCHANDL experimented with *impure beer-yeast* viz., yeast composed of a number of ferments that after a certain time contaminate it and render it unsuitable for fermentation. He analysed the impure yeast of the F. CZELL brewing at Monostor, and found it to contain: water 87.67 % — dry matter 12.33 — albuminoids 6.69 — fat 0.14 — N-free extracts 4.49 — ash 1.01.

This yeast cannot be fed to stock in the condition it leaves the brewery, for it contains too many ferments, has a bitter taste and a disagreeable smell. SCHANDL found that after it was cooked sheep and swine would eat it readily, while horses and cows made no objection to it after 24 hours when the unpleasant taste and smell had passed off.

No bad effects resulted from feeding to two rams 750 gm. of chopped clover + 250 gm. of yeast ; 97.86 % of the albuminoids were digested, 82.86 % of the N-free extracts and 89.54 % of dry protein which speaks well for the availability of the yeast. According to KELLNER'S figures, the starch value is 9.871 gm. for 100 gm. of yeast.

Beer yeast had no special effect in increasing the milk yield of dairy cows to which it was fed at the rate of 5 kg. per head and per day as a supplement to the basal ration (1).

Wine-lees, after being washed so as to remove the tartaric acid, leave a residue that can be pressed and made into cakes. KLING

(1) Beer yeast was also given to dairy cows in Bohemia and the results obtained were superior to those produced by peanut cake. Cf. *Zemedělskárada Prokralovstvi české Cessky-Odbor*, V Kterém Smeru Chovu Donjniclze nejlépe používati sušenych kvasnic Pivovarsky-chza Náhrradu Pokrutin ? V. Prague, 1917.

tried it on pigs in Germany and found the animals digested it well. The percentage composition of this residue is as follows: water 60.33 — crude protein 12.86 — crude fat 5.47 — N-free extracts 3.80 — crude fibre 14.62 — ash 2.92 — tartaric acid that can be neutralised with calcium carbonate 1.65 (KLING).

This residue soon alters and becomes mucilaginous, therefore it should be eaten fresh. The author recommends the crude yeast used to make this cake being first cooked.

The daily rations per head are: for dairy cows 1.5 to 2 kg.; for swine 0.200 to 1 kg.

During the war, a large quantity of *artificial* or *mineral yeast* ("Kunsthefe", "Mineralhefe") was manufactured by a process invented by the "Institut für Gärungsgewerbe" (Institute of Fermentation Industries) of Berlin. In many factories, molasses, ammoniacal salts and other mineral substances were used in making "artificial yeast" which was chiefly used for human food, the small surplus being fed to live-stock. In order to prepare 10 metric tons of this ferment, 30 metric tons of molasses were required in addition to the ammoniacal salts.

LASSAR COLIN, in 1916, suggested substituting urea for the ammoniacal salts, and cultivating these yeasts in premises adjoining large stables or cow-sheds, so that the product could be fed undried to the animals.

In 1917, QUADE proposed that the molasses should be replaced by the waste waters from starch factories or by potatoes boiled with sulphuric acid, by hydrolysed fibre, the washing-water from wood or straw cellulose factories, or even by peat, moss, lichens, etc.

Dr. MEYER estimates the starch valued of mineral yeast at 56.9. The following are two analyses made respectively by VÖLTZ and MEYER: water 5.9 and 11.5 % — crude protein 52.6 and 45.1 % — crude fat 5.8 % — N-free extracts 24.6 and 25.1 % — crude fibre 0-0 — ash 11.1 and 18.3 %.

By means of a special process (not described), a yeast very rich in fat ("Fett-hefe") is made. Its percentage composition is as follows: crude protein 31.4 — crude fat 17.1 — N-free extract 43.4 — ash 8.1 (LINDNER).

25. — Grape residues and Grape seeds (1).

Grape residues make a stock-feed before and after fermentation, as well as before and after exhaustion with water.

(1) A. BRUTTINI. *Diz. d'Agr.* Vol. II. Milan, 1901 — 2) J. FRITSCH, op. cit. — 3) A. MENOZZI and V. NICCOLI, *Alimentazione del bestiame*, Milan, Hoepli, 1911 — 4) OTTAVI-MARESCALCHI, *I residui della vinificazione*, Casalmonferrato, 1901 — 5) Dr. M. KLING, op. cit. — 6) 7. RABAK, The Utilisation of Waste Raisin Seeds. *U. S. Dep. of Agr. Bur. of Plant Ind., Bull.* No. 276. Washington, 1913.

Chemical composition of grape residues previous to and subsequent to exhaustion with water (according to MÜNTZ).

	Unexhausted grape residues	Exhausted residues
Water	57.20 %	63.70 %
Nitrogenous substances	4.28	4.16
Fat	1.01	1.00
Amides etc.	19.06	17.86
Fibre	8.13	8.13
Alcohol	6.50	traces

WOLFF gives the percentage composition as: water 65 — ash 3.67 — phosphoric acid 0.46 — potash 1.72 — lime 0.4 — magnesium 0.15 — soda 0.02 — sulphuric acid 0.18 — silicic acid 0.38 — chlorine 0.02.

According to O. OTTAVI, 1000 parts of fresh residue contain on an average: 280 p. stalks — 520 p. skins — 200 p. seeds. The residue represents 25 % of the weight of grapes, or half of the the wine produced.

100 kilogrammes of unwashed residue as it leaves the press gives about 4 litres of water-free alcohol, or industrially, 8-14 litres of 50 % brandy + 2 kg. of refined cream of tartar (2.5 to 3 kg. of the commercial product), 50 gm. of tartaric acid, 15 to 20 kg. seeds and 30 kg. stripped stalks and skins. Grape residues from which the stalks have been removed contain 67 % skins and 33 % seeds. The distilled residue has the following percentage composition: water 58 to 66 — stalks 20-33 skins 2-3 — seeds 12-16.

Oenocyanin and glycerine are also extracted from grape residues.

The stalks and to a still greater extent the skins make a good stock-feed. The food-value of grape residue is about half that of average meadow hay. As grape residues are difficult to keep, they must be protected from all contact with the air by means of severe pressure in extremely tightly-packed silos. With every precaution, the portions touching the walls decompose rapidly and have to be removed and used as a fertiliser. One cubic metre of well-compressed residue may weigh 700 kg.

A better method than the one described above is to dry the residues in the sun, or by means of artificial heat until they contain only 13 to 15 % of water. In this condition, their food value is equal to that of meadow hay. Residues of stripped grapes dried in super-heated air contained: water 6 % — protein 14.23 % — N-free extracts 60.25 % — fat 6.52 — ligneous matter 4.54 % — ash 8.43.

32 kg. of dried residue is equivalent to 100 kg. of fresh residue.

Ground grape residues mixed with molasses (40 %) are often fed to live-stock. The addition of molasses makes them keep well and the food value of the mixture is very similar to that of oats.

The *seeds* make up about $^1/_5$ of the weight of the fresh residues. They can be separated from the dry residues by means of a sieve.

Grape-seeds are rich in easily-assimilated mineral and nitrogenous matters, but also contain much oenotannin (about 5 %) and hence cannot be classified among the really good stock-feeds.

After the oil has been extracted from the seeds (see p. 327) a cake remains that can be fed to animals (according to CORNEVIN, cattle may be given 11 to 13 lbs. per day) mixed with bran, sharps, potatoes, beets, molasses etc, or in mashes. It is also fed whole, or mixed with oats, to live-stock including poultry, but only in limited quantities.

The percentage composition of the whole seeds is as follows: water 13.40 — crude protein 10 — fat 7 — N-free extracts 35.16 — crude fibre 29.52 — ash 4.92.

Messrs MENOZZI and NICCOLI give the following as the average percentage composition: digestible albuminoids 2.86 — fat 3.74 — N-free extracts 20.22 — nutritive ratio 1 : 10.2 — commercial units 36.28.

KLING quotes the following analyses.

	Grape-seed cake		Dried grape-seed residues	
	I. — 1916	II. — 1917	Th. OMEIS	H. KEIL
Water	7.1 %	10.0 %	9.9 %	10.4 %
Crude protein	14.2	10.7	11.9	9.7
Crude fat	7.1	1.1	4.3	2.6
N-free extracts	33.7	30.5	21.3	27.8
Crude fibre	28.8	47.1	46.7	44.5
Ash	9.1	6.0	5.9	5.0

The percentage composition of grape-seeds ash is: potash 27.87 — lime 32.18 — magnesium 8.53 — oxide of iron 0.46 — oxide of manganese 0.35 — silicic acid 0.95 — sulphuric acid 2.40 — phosphoric anhyd. 27.01 (CRASSO). Other analyses of the ash (3.3 %) give somewhat different results: phosphoric anhyd. 16.71 % — potash 33 %. (DEGRULLY). PARIS found respectively: 22.93 and 21.52 %.

This ash forms a good fertiliser. In Lombardy, Piedmont, Emilia and Apulia there are factories where oil is extracted from grape-seeds.

No first hand information is forthcoming as to any important stock-feeding experiments with grape-seed flour after extraction of the oil with solvents. The "Olierie e Saponerie meridionali" of Bari have informed us that the few laboratory experiments made have given results of little practical value. At present, these residues are used as a fuel which purpose they answer very well.

This confirms what has already been said as to the food qualities of grape-seeds, but for further reference there is added the following results of two percentage analyses made at the " R. Stazione Agraria per l'Aridocultura " of Bari, forwarded by the " Distillerie Italiane " of Barletta.

	Grape-seed cake mixed with molasses	Grape-seed flour
Moisture	11.03 %	12.83 %
Crude protein	7.98	8.31
Fat	5.82	6.11
Reducing sugar	0.00	0.00
Saccharose	1.79	0.00
Fibre	43.47	52.59
Ash	5.99	5.23
Phosphoric acid of ash	16.79	17.42

As might be expected, the utilisation of grape residues in Germany during the War was on a scale quite beyond that found in any other vine-growing country.

From the autumn of 1916, grape residues were commandeered. They were dried, and the most of the seeds removed by sifting. The skins and stalks together with the small quantity of seeds remaining were dried and ground to *residue flour* (or enofarine). The seeds were generally used for making oil and oil-cake.

The digestibility of this flour proved to be low, 31 % of the organic matter, 14 % of the crude protein, 55 % of the crude fat, 36 % N-free extracts and 27 % crude fibre being available. According as treated, the crude fibre content ranged from 20 to over 40 %.

The amount of the flour that can be added to the rations fed to live-stock may be as much as 2.5 lbs. per head per day for cattle — 1.1 lb. for sheep — still less for horses. None must be given to swine.

The following are the percentages obtained in two analyses by Kling: water 6.9-11.2 — crude protein 13.5-13.2 — crude fat 6.4-4.5 — N-free extracts 46.1-31.4 — crude fibre 20.5-31.8 — ash 6.6-7.9.

A flour of grape residues disintegrated in some way (the method is not stated but it is probably one of the processes described in the case of straws, see p. 92) had the following percentage composition according to Kling: — water 15 — crude protein 12.5 — crude fat 5.4 — N-free extracts 23.6 — crude fibre 28.6 — ash 14.9. The disintegration process increased its digestibility, but only to a negligible extent, hence it was practically to be reckoned as a undisintegrated flour.

26. — Apple, Pear, and Service-berry residues (1).

The apple residues consist of the pulp which has been crushed and washed several times in order to extract the juice for cider-making. When unaltered, this pulp can be profitably fed either fresh, or dry, to live-stock.

The same applies to the residues of the pears used for perry.

From one ton of apples, about one quarter of residues results. The average, immediate, percentage composition of the latter is as follows : water 74.10 — nitrogenous substances 1.65 — fat 1.35 — sugars 3.15 — carbohydrates 5.10 — fibre 12.55 — ash 2.50. Wolff found these residues contained the following digestible nutritive substances : albuminoids 0.7 — N-free extracts 12.1 — fats 0.5 — nutritive ratio 1 : 19.1.

Live-stock readily eat these residues either fresh or dry, if mixed with straw, bran, etc. They are fed soaked in water to pigs in the proportion of $^1/_4$ to $^1/_{10}$ of the normal ration.

As these residues quickly alter in the air, they are mixed with wheat chaff or straw and silaged, after the addition of a little salt, under heavy pressure.

Apple and pear pomace are principally fed to the live-stock in the neighbourhood of cider and perry factories, and as the quantity produced in cider and perry making countries amounts to some tens of thousands of tons, these residues are worth taking into account.

When they have turned sour and are thus unfit for a stock-feed, they are used as a fertiliser, mixed with stable-manure and compost.

The average percentage composition of apple and pear pomace as given by the results of 3 analyses quoted by Kling (2) are shown in the table below.

	Dried residues of	
	Apples	Pears
Water	11.8 %	7.9 %
Crude protein	7.7	5.4
Crude fat	4.0	3.1
N-free extracts	48.2	55.1
Crude cellulose	23.2	24.5
Ash	4.3	3.9

The extraction of the juice from the fruits of the cultivated Service-tree leaves a residue which has been employed as a stock-

(1) Cf. : 1) Razous, op. cit. — 2) *The Journal of the Board of Agriculture*, Vol. XXII, No. 9 and Vol. XXIV, No. 5. London, 1915, and 1917.

(2) Dr. Max Kling, op. cit., pp. 145-146.

feed in Germany. According to KLING it has an average percentage composition of: water 60.6 — crude protein 5.1 — crude fat 4.6 — N-free extracts 23.0 — crude fibre 5.4 — ash 1.3.

Mention should also be made of the residues of the *fruits of the arbutus* (*Arbutus Unedo* L.). The sugary juice of these berries is used in the manufacture of alcohol, and the pulp, if fed at once, makes a good ration for stock. It contains, according to Prof. F. LA MARCA (1): water 14 % — protein substances 13.45 — N-free extracts 31.05 — fibre 34.30 — fat 6 — mineral substances 1.20 — commercial nutritive unit 71.28.

Currant residues (2) coming from the factories of preserves, syrups and beverages are especially rich in fat. According to BOUCHER, 100 parts contain: 63.83 parts of water and substances volatile at 100° C — 4.49 nitrogenous matter — 8.30 fat — 8.69 N-free extracts — 9.41 fibre — 5.28 mineral substances.

These residues are fed dry or silaged. Sheep may be given 1.5 kg. of fresh currant residue and 300 gm. of the dried residue per head and per day.

27. — Tomato residues (3).

Now that the preserved tomato industry has become of such importance, especially in Italy, the quantities of the skins and seeds of these fruits left after the juice has been extracted are very large.

It has long been known that these residues can be employed as a stock-feed and a source of oil, but the large quantity of material now available at the factories makes a still fuller use possible.

Numerous researches have been undertaken, and much has been published on the subject of the utilisation of these waste products, which can also be turned to account as a fertiliser and fuel. The former is the more profitable use.

Chemical composition of dry tomato residues
(*flour made from the seeds and skins*).

	Crude substances	Digestibility coefficient	Digestible substances
Water	6.8 %	—	—
Ash	6.2	—	—
Protein	23.1	77.83 %	17.98
Fat	20.5	98.47	20.18
Fibre	25.56	—	17.84
N-free extracts	17.84	—	

(1) F. LA MARCA. *Il Corbezzolo*, Casale, Marescalchi, 1914.

(2) Cf. R. GOUIN, op. cit., p. 229.

(3) *a*) ACCOMAZZO, P. Utilizzazione dei residui della lavorazione del pomodoro. Parma. *Riv. di Agric.*, 1920; *b*) Italy occupies the first place among tomato-growing countries; her

When these residues consist of seeds without any admixture of skins, they probably come under the head of KELLNER'S "full return" foods, since there is very little loss during digestion.

Tomato residues if given fresh should be fed within 48 hours, but they are apt to disagree with live-stock, and hence it is preferable to dry and grind them to rather coarse flour. The oil is always first extracted from the seeds. The flour is fed to cattle in the form of a mash which they soon learn to like and eat with avidity.

In the author's experiments, neither horses nor swine would touch these residues. Animals that would eat them kept in excellent condition. They can be fed either alone, in mashes, or mixed with fodder. Small quantities with a little salt must be given at first, and the amount increased after 5 or 6 days. These residues have no bad effect on the milk of dairy cows.

Characters of the flour. — The flour is ground with the Bamford mill, and also by means of ordinary grindstones. It is brownish-red, and has a pleasant smell of tomato combined with a slightly bitter, but not disagreeable flavour. If the oil had not previously been extracted, the flour is greasy to the touch. Its specific gravity is 0.40-0.45. It keeps well for a long time if stored in a dry place. Even when whole, it is not alone sufficient to satisfy the requirements of dairy-cows or growing cattle, but must be supplemented by suitable additions. Theoretically a unit of hay is equal to 0.62 of this residue.

ACCOMAZZO advises 100 parts of hay being mixed with 84 parts of tomato residue. A cow weighing 1100 lbs. that should daily consume 28.6 lbs. of dry matter may be fed 32.2 lb. of this mixture. Fully grown oxen when not at work, and weighing 1100 lbs. need 20.4 lbs. of dry matter a day, this can be supplied to them in the form of 22 lb. of a mixture of 100 parts straw, and 30 parts tomato residue flour.

A complex feed containing tomato residues (1). — This is prepared by mixing in constant proportions: linseed-cake meal, molasses, tomato residues and intact grape-seeds. The following percentage have been obtained by analyses: moisture 9.5 — crude protein 15 — crude fat 8.8 — fibre 23.7 — ash 5.8 — N-free extracts 37.2 — digestible protein 10.62.

Experiments were made on 19 growing steers of the Brown Alpine breed, this complex food being used to replace part of the hay and oats rations.

annual average production for the period 1909-1903 has been estimated at about 500,000 metric tons. In 1913, 46,700 tons of preserved tomatoes were exported from Italy; they were sent principally to England; *c*) The total number of tons of tomatoes pulped in the United States in the largest factories between 1914 and 1918 were respectively 68.697; 56,835; 87,439; 102,047 and 140,185.

The annual quantity of seeds containing 10 % of moisture obtained from the large factories alone is 1,026 tons; this allows 0.5 to 1 kg. per 100 kg. of tomatoes. In 1918, the output of seeds from all the factories was estimated at 2,063 tons. (Cf. *United States Dep. of Agr. Bull.*, No. 927. Washington, April 1921).

(1) Dr. D. BRENTANA, *Alcune osservazioni sull'uso di un mangime concentrato* (*Nutritivo Squassi*) *nell'alimentazione del bestiame bovino*. Parma, tip. Parmense, 1921.

As regards the nutritive value of the foods, 1.5 lbs. of this *Nutritivo Squassi* is equivalent of 2 lbs. of hay, and 1 lb. to 0.7 lb. of oats.

All the animals became accustomed to this food within the short space of one week. It was given to the several lots daily for 30 days, at the rate of 1.5 lbs. (0.75 kg.) to 3 lbs. (1.50 kg.) per head, together with the other above-mentioned substances.

Nutritivo agreed well with the animals on which it was tried, their increase in liveweight being greater than that of other cattle to whose rations it had not been added.

As regards the economic results, Mr. BRENTANA estimates the cost of the nutritive unit as follows: hay 2 *liras* — oats 1.90 *liras* — *Nutritivo* 1.87 *liras*.

The author is of opinion that *Nutritivo* has undoubtedly a certain value as a stock-feed, and might become of considerable importance, as supplying a profitable use for the residues of the tomato, a plant now becoming widely cultivated.

28. — Residues of Citrus Fruits.

When the juice of lemons is employed in the manufacture of *agro cotto*, or calcium citrate, or when it is merely concentrated by the action of heat or cold, the pulp and skins remain, previously *sfumate* (1) to extract the essential oil. Similar residues are obtained in the case of oranges.

According to Prof. GARELLI (2), the fresh and the fermented residues have respectively the following percentage composition: total nitrogen 0.6-1.4 — protein nitrogen 0.4-0.8 — crude fat 1-5.5 — N-free extracts 61.3-82.2 — crude fibre 9.2-21.8- — ash 4.3-6.5.

The fermented residues are richer in nitrogen and more readily eaten by live-stock than the fresh residues.

They are usually given to cattle (3).

29. — Parings from Vegetable Ivory (4).

These consist of the dust and shavings obtained in working the seed albumen of different species of plants used for making buttons (*corozo*). The industry has now assumed considerable importance

(1) " Sfumare " is the term applied in Sicily to the extraction of the essential oil by pressing the skins of citrus fruits.

(2) *Le Stazioni Sperimentali Agrarie Italiane*, Modena, 1899.

(3) POTT, E., op. cit. vol. III, p. 481.

(4) Cf. : 1) *L'Italia agricola*, Year LVI, No. 2. Placentia, 1919. — 2) FORMENTI, *Residui agricoli*, Milan, 1915, Hoepli, p. 361. — 3) *Journal of the Society of Chemical Industry*, Vol. 37, No. 12. London, 1918. — 4) *Journal of Agricultural Research*, Vol. VII, No. 7. Washington, 1916. — 5) POTT, op. cit., Vol. III, p. 481.

and the residues, which form a good stock-feed, amount in the year to several thousands of tons (1).

Hyphaene thebaica (a native of Erithrea) supplies most of the seeds used for buttons in Europe, while in America the seeds of *Phytelephas macrocarpa* (from Columbia, Ecuador and N. Peru) and of *Ph. microcarpa* are chiefly employed for the purpose. The seed albumen of the latter plant is the harder. Buttons are also manufactured from the seeds of *Sagus americanum*.

During the process are obtained: the *saw-dust*, the centre of the broken seed, the *dust* and the *turning shavings*.

These are the residues used as a stock-feed. They make up 85 % of the worked kernels, and form a white, light powder used also as a substitute for coffee.

The corozo of Erithrea (*dum*) has the following percentage composition: moisture 10.35 — crude protein 4.70 — fat 10.20 — fibre 14 — pentosans 2.10 — N-free extracts (without pentosans) 59. (MENOZZI).

C. BEALS and J. B. LINDSEY obtained as the average of 9 samples of American corozo: water 11.39 % — ash 1.08 — protein 4.63 — fat 0.92 — fibre 6.89 — N-free extracts 75.09. The latter includes 92.5 % of mannan (condensation anhydride of mannose) and 2.5 % of pentosans. Lignin, starch and dextrose are absent. Its energy value is 3785 calories e. g. nearly the same as that of maize flour, sugar and starch.

The percentage coefficients of this corozo are as follows: dry matter 84 — protein 36 — fat 51 — fibre 72 — N-free extracts 92. To these coefficients correspond the following quantities of digestible substances in 100 kg.: protein 1.89 — fat 0.30 — fibre 4.51 — N-free extracts 70.55 — total 77.25. Maize flour gives a total of 76.37.

(1) In 1916, about 10,000 tons of these residues were imported by the United States alone. Italy disposes annually of about 4000 tons. The following data show the importance of this industry:

Corozo buttons are made in Italy, Germany, Bohemia, France, Great Britain and the United States. Previous to the war, Italy turned out 50,000 gross of buttons a day, but at the termination of hostilities this production had fallen to 30-35,000 gross of which some were exported (1,964 tons in 1913 and 2,240 tons in 1920).

In Italy, the seeds of the *dum* palm (from Erithrea) are almost exclusively used for button manufacture, but in other countries, the *tagua* of Columbia etc. are employed for the purpose. 2,534 m. tons of *dum* seeds were imported in 1914 and 2,647 m. tons in 1920.

Bohemia, France, Great Britain, the United States (2 factories) although producers of corozo buttons also import them.

Large quantities are produced in Germany, a rival of Italy in the button-trade. These two countries have at their disposal the largest amounts of corozo residues destined for stock-feeding (Cf. MIN. PER L'IND. ED IL COMM). *Il nostro commercio di esportazione prima e dopo la guerra*. Rome, 1922, p. 124).

Prof. I. BALDRATI, who employs the sawdust of *Hyphanene thebaica* of the Cheren saw-mills, along with bran and cake for dairy cattle, reports that this residue damped or slightly fermented acquires a sweetish flavour, liked by stock. The husks of the fruits are good fuel and their ash is rich in potash and phosphoric acid. The sarcocarp or pulp of the fruit is rich in sugar and an enquiry has been set on foot with a view to its use in the manufacture of alcohol. (Cf. *Il Coltivatore*, No. 13. Casalmonferrato, 1923).

According to the American inventor of a patented process (CHAPMAN *R. M.* etc.) this residue is made more digestible by heating it to 138°-160° C in a bath containing 1 to 2 % of sulphuric acid, or a similar disintegrating fluid, until it become friable and can be ground into flour.

Vegetable ivory flour fed to 10 cattle for 24 days in quantities gradually increased from 1 to 6.5 lbs. a day increased the total live-weight 27.75 lbs. as against 29.75 lbs. in the case of the control group.

Dairy cows will eat this flour, provided it is mixed with other foods. On feeding 3 lbs. a day, the milk yield increased 2 lbs. for every 7 lbs. of ivory flour, but for milk production this residue is not quite equal to maize flour. Sheep will eat it readily if it is mixed with other foods, and seem able to assimilate all its carbohydrates.

According to C. BRIDOUX (1), corozo flour is superior to groundnut husks, and rice husks, but inferior to maize flour. Its crude starch value is said to be 76 % but the net value is probably only 45, %, the same as that of bran. This flour does well for mixing with other substances richer in nitrogenous substancse.

30. — Sweepings and Household refuse.

When dealing with fertilisers, the various ways in which the above residues can be used for manuring the soil will be enumerated (see p. 303). Here, we will confine ourselves to stating that an attempt was made in the United States to employ household refuse (after the fat has been extracted) as a stock feed under the name of garbage, the heavier substances being separated by the flotation process. The nutritive value of these residues is naturally variable, but it must be remembered that the Americans do not class under the head of "garbage" inert substances such as horns, ashes, paper, glass, tins and street-sweepings.

It has been found that an average of 50 lb. of garbage are needed to obtain 1 lb. increase of live-weight in a pig ; naturally, supplementary foods were also given. The meat of animals thus fed proved excellent. Sweepings intended for this purpose must be collected frequently and freed from all such extraneous substances.

These residues generally suit pigs better raw than cooked. They must be fed with caution, as swine given garbage have been found to be more subject to diseases than those that receive grain (fig. 55).

F. G. ASHBROOK and J. D. BEBOUT (1) have demonstrated the use of sweepings as a swine-feed. These residues are thus much better turned to account than by burning, or conversion into fertiliser, etc. In 1917, seven out of 17 cities in the United States were found on enquiry to feed their sweepings to swine.

(1) Cfr. *Comptes rendus de l'Académie-d'Agriculture*, Vol. IV, Paris, 1918.

(2) Disposal of City Garbage by Feeding to Hogs. *Circular* No. 50, *United States Dep. of Agr.*, Dec. 1917. Washington.

Owing to the variable composition of these residues, it is impossible to state the usual amount to be employed. In the United States, it is however reckoned that 4 tons of sweepings are required for a pig weighing 200 lb., for a period of 10-12 months.

It is well to boil and sterilise the sweepings before feeding them, as this treatment allows of the separation of the fat which is regarded by some farmers as injurious to swine ; further, it removes any danger of infection. The process is, however, expensive and best followed in winter when the amount of fat present in the garbage is higher. Swine fed on raw garbage are rarely free from skin diseases and intestinal worms, whereas pigs which have been given boiled garbage escape these troubles.

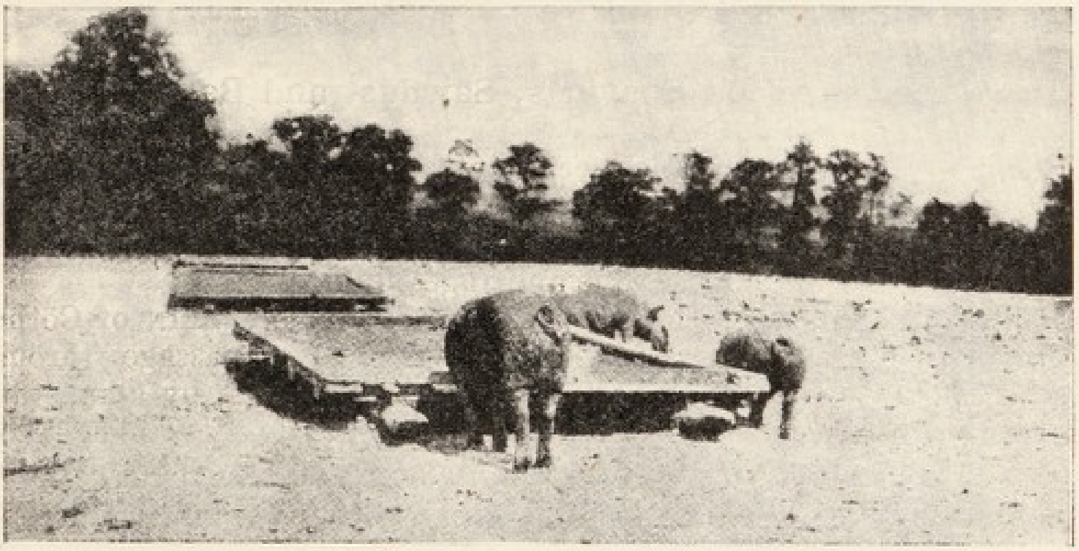


FIG. 55. — Platform for feeding household refuse to pigs.

From *U. S. Dept. of Agr., Farmer's Bull.* 1133. Washington, 1920.

31. — Wood Ashes and Charcoal.

Wood Ashes. — It is well-known that common salt has a stimulating action and improves the digestion of live-stock, and on all well-managed farms, blocks and sacks of salt are put within reach of the animals, especially of the cattle and sheep. Animals, however, also require a small amount of potash, and as this is rarely present in their food, it is advisable to supply it by the addition to the ration of a small quantity of very fine, clean wood ashes : 4 to 10 gm. per 100 kg. of live-weight, per day according to the age of the stock.

Although many cases have been known of animals consuming without any injury large amounts of potassic salts, it must not be forgotten that too large doses of potash may produce digestive, muscular, nervous and cardiac troubles.

Young animals and poultry, which need considerable quantities of phosphoric acid and lime, are given bone-dust. This may be replaced by wood-ashes which are always easily obtained. They are sifted very fine and then washed to extract the potash. It is unnecessary to free the ashes from the small fragments of charcoal that are always present.

The average amounts of ashes to be given daily per head and per day are: 15-25 gm. for young cattle — 10-15 gm. adult cattle — 10-15 gm. calves from 2 weeks to 5 months — 5-10 gm. horses — 3-4 gm. swine — 10-15 gm. sheep — 4-6 gm. fowls — 1-2 gm. rabbits.

When possible, it is preferable to administer the ashes in milk.

Wood Charcoal. — This is a good intestinal antiseptic; it can be fed, not only mixed with ashes, but also alone with the forage, as is frequently done in England in the case of sheep. Wood charcoal is good for all live-stock including poultry from the very first stage, and up to any age.

32. — Wood Shavings, Sawdust and Bark.

The great dearth of stock-feeds during the War led some persons to experiment once again (1) with more or less finely ground wood subjected to a special treatment for the purpose of rendering a variable portion of the fibre soluble and digestible.

In the patented process invented by H. MÜHLENBEIN of Cöthen (Germany), the wood is finely ground during its passage through special apparatus, and is then acted upon in digesters by alkalis and oxidising substances such as chlorine; subsequently after being separated from the liquid and washed, the wood is mixed with other foods and dried with them.

Experiments were also made with wood-shavings during the war; they must be reduced to powder before being fed, otherwise the stock will not touch them.

I. BILLITTERI of Palermo (2) has recently used wood-shavings instead of straw. They were enclosed in a recipient, subjected to an early stage of the carbonisation process, and then the mass, by this time very brittle, was ground.

During the war therefore, wood-sawdust was actually used as a stock-feed, although previously it had been tried and found unsatisfactory.

New experiments were carried out during the war in Germany, and at the conclusion of hostilities in the United States at the Wisconsin Agricultural College. In every case, the sawdust must be chemically treated in order to convert the fibre into sugar; this is effected by the action of dilute acids, the sawdust being boiled for ¼ hour in dilute sulphuric, or hydrochloric acid, and under pressure (fig. 56). By this means, 20 % of the sawdust is transformed into sugar, while the rest is made more digestible. The sugar is extracted with

(1) The use of wood was tried many years ago by STÖCKHARDT and other authors. Cf. POTT, E., op. cit., Vol. III, p. 486 and also KLING, Dr. MAX, op. cit., p. 61.

(2) I. BILLITTERI, *Alimentazione gratuita* etc., p. 66. Palermo, 1921.

hot water in which the excess acid is neutralised, and afterwards the liquid is evaporated till it reaches the consistency of a syrup. This latter is mixed with the residue that has not been converted into sugar and a stock-feed very poor in nitrogenous substances is thus obtained. In the experiments made at Wisconsin, each pound of barley meal in the ration was replaced by 2 pounds of prepared sawdust, the latter forming 26 % of the weight of the ration.

Very satisfactory results were obtained with dairy-cows.

From White Pine sawdust 14-18 parts of sugar were obtained from every 100 parts of dry wood.

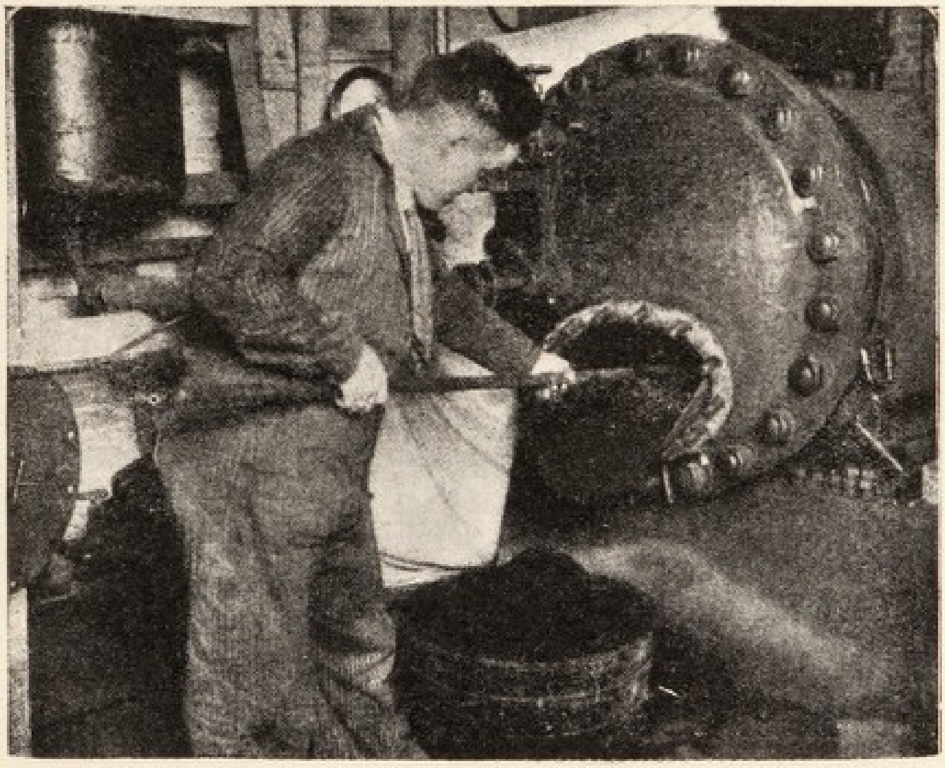


FIG. 56. — Taking out sawdust after hydrolisation in an autoclave.
From *U. S. Dept. of Agr.* Yearbook 1920.

The following is a good ration for dairy-cows: hydrolised sawdust 25 parts, oats 30 parts, wheat bran 30 parts, semolina flour 15 parts (1).

It should be observed that this process requires a particular apparatus, special facilities and some knowledge of industrial chemistry, it is thus not suited to any and every farm.

In conclusion, it is in every case described a question of wood viz., of a substance which, even if treated so as to convert all its fibre into sugar, does not merit the name of a food properly so-called. In time of extreme necessity, it can be used to dilute concentrated feeds for ruminants only and is never anything more than a make weight.

(1) DANA, S. T. Putting wood waste to work, from the *Yearbook of the U. S. Dept. of Agr.*, 1920, No. 856.

The best sawdust for feeding purposes comes from the beech and from deciduous trees in general (POTT), as their wood contains gummy substances (19.7 to 23.8 %) which are soluble in water, and yield xylose on treatment with dilute acids.

Oak sawdust is not however good on account of its tannin, while pine sawdust may be injurious as it is rich in resin.

The following table gives some analyses:

	Pine-wood flour according to W. ELLEMBERGER and P. VAENTIG	Birch-wood straw according to ZUNTZ and VON DER HEIDE	According to KLING	
			Flour of wood of deciduous trees	Young birch-wood
Water	7.4 %	4.5 %	9.8 %	—
Crude protein	1.0	0.7	0.5	1.8 %
Crude fat	0.3	0.4	0.8	0.9
N-free extracts	26.2	61.4	37.3	54.2
Crude fibre	64.7	32.5	49.9	42.7
Mineral substances	0.4	0.5	1.7	0.4

The following analyses made by BECKMANN show that starch only occurs in negligible quantities, and that it is not true, as was supposed before the war, that sap-wood contains sufficient digestible starch to repay making it into a meal for mixing with bread.

Wood	Crude protein	Fat	Starch	Ash
Maple	1.6 %	0.5 %	2.6 %	0.8 %
Birch	1.1	1.3	0.9	0.7
Alder	1.9	0.5	1.5	0.7
Elm	2.0	0.4	5.9	0.9

According to KELLNER only 14 % of the organic matter and hardly any of the nitrogenous substances in wood are digested.

HONCAMP obtained even lower values. WAENTIG found that in boiled pine shavings given to horses 7.5 % of the dry matter and 10.3 % of the crude fibre was digestible, the nitrogen balance being negative.

The best results were obtained, as we have said, from *disintegrated sawdust* treated with sulphuric acid; from which was obtained a food that according to HONCAMP and his collaborators contained in its dry matter: crude protein 0.7 % — crude fat 1 % — N-free extracts 40.3 — crude fibre 57.3 % — ash 0.7 %. In the case of lambs, the following were the digestibility coefficients: organic matter

20.1 — crude protein 0 — crude fat 73.1 — N-free extract 65 — crude fibre 0.

Thus, disintegration increased the digestibility, but did not render it equal to that of the straw of spring cereals.

Disintegrated wood flour ("Holzzuckerfutter") is prepared by boiling the wood in acids and under pressure. The following are 2 analyses made by Ellenberg and Waentig:

	I	II
Water	9.4 %	8.0 %
Crude protein	0.8	4.7
Crude fat	0.7	2.1
N-free extracts	25.6	29.7
Crude fibre	62.5	37.1
Ash	1.0	1.2

The digestibility of this wood-flour is very low.

A food for cattle, swine and poultry made by the firm of Blankenburg under the name of "Kriegsviehfutter" was said to be composed of ground wood and sifted sawdust subjected to some kind of chemical process, but Schmöger and Kling assert that it consisted simply of the unaltered sawdust of deciduous trees moistened with a solution of sodium chloride. Its percentage composition is as follows: water 36.0 — crude protein 0.4 — crude fat 0.2 — N-free extracts 22.7 — crude fibre 38.7 — ash 2.2.

"Rindermehl" was a flour of dried bark from which the fibre had been separated by a special milling. It was supposed to be free of tannin, but in reality contained a large amount of that substance.

The following table gives its percentage composition:

	I	aI
Water	10.5 %	6.9 %
Crude protein	4.9	4.2
Crude fat	1.7	2.8
N-free extracts	38.8	34.2
Crude fibre	31.4	45.5
Ash	12.7	6.4

Experiments conducted by Richardsen have shown that this flour can be fed to dairy cows.

The residues of the bark (of oaks and other trees) that have been used for the extraction of tannin and are nearly tannin-free may be used as roughage, but are preferably mixed with molasses (1).

33. — Residues from Cardboard and Cellulose Factories (2).

In the process patented by C. H. Voigt, the residues of the digesters are neutralised by sulphuric acid, in order to remove the alkaline substances with which the raw materials were treated. By this means is obtained a fine precipitate consisting for the most part of organic matter. After it has been isolated by the filter-press, heated, well washed and again pressed, it forms a cake which is dried and fed to stock. It agrees well with horses, cattle and sheep.

Pott is doubtful of this new feed, as detailed information is not forthcoming.

A. Frank proposes using the water from the cellulose factories after it has been freed from aldehydes, cetones, and sulphites, and evaporated on absorbent substances like husks, straw, beet root pulp etc. This water contains large quantities of carbohydrates and of mineral substances (potash, phosphoric acid etc.)

After it was purified, made into syrup and steam dried, Frank obtained from this residue 16 to 18 % of sugar, but according to Pott the cost of these operations far exceeds the value of the food. It is better employed on the spot to moisten bulky fodders.

Sulphite cellulose is produced in the cellulose factories by prolonged boiling under pressure at 110-140° C with calcium sulphite lye, during which about 60 % of the dry matter is lost. This substance forms a moist paste, and had the following percentage composition after being air-dried and ground.

	Ellenberger and Waentig analysis	Schmöger's analysis (Dry matter)
Water	8.9 %	—
Crude protein	—	0.9 %
Crude fat	0.4	0.9
N-free extracts	17.0	17.2
Crude fibre	72.4	79.7
Ash	1.3	1.3

(1) Other uses to which wood sawdust is put are as follows : " spolvero " for ovens, the purification of oils, smoking dried meats, packing-material, strewing on floors of gymnasiums, riding-schools etc., removing fat from hides, etc., drying gilded metal etc., purifying gas, the manufacture of cement, preparation of the matrices in metal moulds, heating special ovens, poor-gas engines, the manufacture of conglomerates, etc.

(2) Cfr. 1) Pott, op. cit., Vol. III, p. 485 — 2) Dr. Max Kling, op. cit., p. 65 et sqq.

Soda cellulose (" Natronzellulose ") was also made by treating the saw-dust of conifer wood with soda lye containing different sulphur compounds. Its percentage composition is given below.

	Spruce wood	Pine wood
Water	6.6 %	5.8 %
Crude protein	0.8	0.5
Crude fat	0.2	0.2
N-free extracts	19.2	14.0
Crude fibre	71.4	77.3
Ash	1.8	2.2

Its digestibility coefficients in experiments with horses were found to be: spruce cellulose 87.9 % — pine cellulose 83.9 % e. g. higher than that of sulphite cellulose.

Professors F. SCURTI and V. VEZZANI (1) using maize rachides and wheat straw pulverised and treated in an autoclave with mineral acids prepared a cellulose paste which supplemented by molasses gave good results with cattle, swine, rabbits and poultry.

34. — Coffee Grounds and Chicory Dust (2).

D. BRENTANA has tried giving coffee grounds to oxen and dairy cows in Italy; for this purpose, he used the grounds of the first infusion after grinding them. Not all the animals would eat these residues; cows accepted them after a certain amount of repugnance, and consumed 700 gm. per head per day without any ill effects. In the case of work-oxen, it was found possible to replace half the bran ration by coffee grounds without causing digestive trouble.

In many parts of Germany, during the War, coffee grounds were collected and fed to live-stock. According to C. BEYER, the digestibility of their crude protein is very low: 11 to 20 %.

As regards composition, coffee grounds are comparable to coarse wheat bran and to rice bran. The percentage composition of 2 samples of the second infusion was as follows: water 9.45 and 11.42 — fat 11.64 and 12.45 — nitrogenous matter 11.68 and 11.50 — starch 17.0 and 22.47 — N-free extracts, second sample 14.81 — fibre, second sample 25.30 — ash 1.71 and 2.03.

These residues must be kept very dry and powdery. One cow can eat 2.2 lbs. (1 kg.) a day; an ox 3.3-4.4 lbs. (1.5-2 kg.) on an

(1) *Ann. R. Staz. Chim. Agr.*, Turin 1920, Vol. VIII.

(2) Cf.: 1) BRENTANA, D., *La Riforma agraria*, year 1, No. 7, Parma, 1920. — 2) ARUCH, F., in *L'It. Agric.*, year LV, No. 10. Piacenza, 1918. — 3) KLING, op. cit., p. 74.

average, and a horse 0.8 kg. (1.75 lb.). but not more than 0.4 kg. (0.9 lbs.) should be fed. Coffee grounds improve the composition and quality of cows' milk ; pigs digest the fat they contain exceedingly well.

The chicory residues, except those found mixed with the coffee grounds, are the dust that falls in the places where chicory is roasted and packed. Their percentage composition is as follows : crude protein 4.2 — crude fat 1.1 — carbohydrates 55.6 — inulin about 30 — sand, soil, etc. 16.3 The presence of the latter substance prevents the chicory residues being used as a stock-feed. They have however, been employed in Germany in the adulteration of rye bran.

35. – Tin-Works Bran refuse (1).

In tin-factories, wheat bran mixed with palm-oil is sometimes used for polishing the sheets of metal.

In the United States during the war, this bran was put on the market under the name of "Palmomidds". It was separated from all particles of metal by an electro-magnet.

Although this residue has been found to be a good food, it is not likely to become of much importance owing to the limited amount available. Further, it remains to be seen whether during the polishing process it does not acquire a smell rendering it unpleasant to animals.

36. – Slaughter-house Offals and Carcases (2).

Slaughter-house offals are generally used for manure, as we have said elsewhere (see p. 246), but if properly prepared, they can also be employed for feeding live-stock. Their use for this purpose was greatly intensified during the war and it is this use in the different countries that calls for attention.

Blood. — This may be regarded as the chief residue and the one that can be used for most purposes. It is usually given dried to live-stock.

At the Purdue University (United States), a lot of calves were fed the following mixture : maize flour 8 parts, linseed meal 1 part, liquid blood 12 parts and 1 part steamed ground bones. The mixture was dried at 60° C for 4 to 6 hours, and then ground. Before feeding, it was moistened with a little water and then diluted with tepid water.

The calves given this mixture increased about ½ kg. daily per head.

(1) Cf. *The Board of Agriculture of Ohio*, Vol. VII, No. 4. Columbus, Ohio, 1917.

(2) Cf. : 1) *Purdue Univ. Agr. Exp. St.*, Bull. 246. Lafayette, Ind., 1920. — 2) *The Journ. of the Ministry of Agr.*, London, 1920. — 3) *Deutsche Landw. Pr.*, year XXXII, No. 12. Berlin, 1915. — 4) *Ann. de Chim. anal. et de Chim. appl.*, 2d s., t. 1, No. 2. Paris, 1919. — 5) POHER, E. et RAZOUS, P. *Les Déchêts et Sous-Produits d'Abattoirs, de Boucherie et de Fabriques des Conserves de Viande.* Paris, Dunod et Pinat, 1908. — 6) POTT, E., op. cit., Vol. III. — 7) KLING, Dr. MAX, op. cit. 8) — AEREBOE, Dr. FR. Die Umgestaltung der Deutschen Viehzucht nach dem Kriege. Berlin, P. Parey, 1918, p. 7.

During the war, many firms sold dried blood for a stock-feed. When well prepared, it is a powder with a slight smell and has the pleasant taste of salted meat.

Experiments were made with it in England by L. NEWMANN, who fed dried blood, in addition to a basal ration of maize flour and wheat offal, to 28 pigs. The pigs were divided into 2 equal lots, one control lot and another that consumed 140 lbs. of dried blood in 11 weeks. At first, the pigs did not tolerate their new feed well, but they soon grew accustomed to it.

It is advisable to add about 10 % of phosphate of lime to dried blood powder. Not only cattle, but also fowls, pheasants and turkeys etc. will eat it when mixed into a paste.

If mixed with molasses and absorbent substances like bran, and subsequently dried, blood makes an excellent stock-feed (it is given at the rate of 1 lb. per 500 lbs. of live-weight).

Its percentage chemical composition, according to DUBOYS is: water 7.33 — amides 3.32 — albuminoids 24.62 — fat 1.04 — sugar 7.50 — N-free extracts 42.20 — fibre 7.02 — mineral substances 6.97.

By means of a process patented by F. SGALITZER of Munich, an excellent and digestible food for animals can be made from defibrined blood from the abattoirs by converting it into a congealed mass that is easily soluble in water and then liquidifying and evaporating it at about 30° C under reduced pressure. The dried material must not be heated to above 40° C.

A household method of preparation is to heat the blood to 100° C during the successive separation of the serum and the drying of the coagulum. The coagulum is then ground to an odourless powder which keeps well and can be profitably fed to stock, especially to calves and sheep. When given to young animals, it must be mixed with milk.

Of importance also are the experiments of GAUDUCHEAU (1) who during the war studied the utilisation of blood from the abattoirs either alone, or mixed with various other animals, or plant, residues. The chief principle of his method consists in subjecting these substances to the action of alcohol yeast. In the case of the blood, 3 % sea-salt and 15 % of "hydrochloric hydrolysat of starch" are added. The latter is obtained by heating at 120° C for two hours an aqueous solution of 4 % commercial hydrochloric acid containing 15 % of manioc flour, or some other equivalent starchy substance. Then, a pure culture of alcohol yeast is introduced, and as soon as fermentation has set in, a layer of oil is added to produce anaerobic conditions.

This fermented blood, when given in a small quantity to young rats, greatly increased their growth.

(1) A. GAUDUCHEAU : *a*) *C. R. Ac. des Sc.*, t. CLXVI, 1918, p. 1058. — *b*) *C. R. de la Soc. de Biologie*, t. LXXXIII, No. 30, 1920, p. 1341. — *c*) Sur quelques aliments fermentés utilisables par l'aviculture. *Travaux du Premier Congrès Mondial d'Aviculture* at the Hague-Scheveningen, 5-9 Sept. 1921. Vol. I, p. 118.

Gauducheau suggested at the World's Poultry Congress held at the Hague-Schevenigen in 1921, that experiments should be made to ascertain whether blood would have the same effect on poultry. For the latter, it would probably suffice to add a little fresh blood to their rations.

Ten grammes of dried blood might be given to poultry per head and per day.

Cakes made of blood and bran with pure yeast were fed to ducks by Rempler, a breeder in Eure-et-Loir, and very savoury meat thus obtained.

When special products are not available Gauducheau says that home-made bran or manioc cake would answer the purpose with a little blood added to make it more tasty. This would be a good method of obtaining meat of superior quality, for the flesh of animals fed on these cakes is said to have a special flavour.

Paunch and rumen. — During the war, the German Minister of Agriculture ordered that the managers of public abattoirs were to deliver to pig-breeders the contents of the paunch of cattle, and the blood residues, as soon as the animals were slaughtered. To 100 kg. of this content were added 20 litres of blood, 20 kg. of peat mixed with molasses, 1.5 kg. of salt and a little lime. The food value of 100 kg. of this mixture was equivalent to that of 400 kg. of potatoes.

Beckstroem of Berlin has patented a process in which the contents of the paunch are mixed with chopped hay and peat which absorb all the fluid, and then allowed to ferment at 40° C. until the strong liberation of gas has ceased, after which the mixture is dried. If the contents of the paunch are placed in receptacles having the inner surface of their walls covered with peat, the latter acts as an isolating and absorbent material which retains the peat and takes up the liquid. During fermentation, the fibre is decomposed, and the mixture has a slightly acid reaction, but as soon as liberation of gas ceases, it becomes almost neutral. The unpleasant odour at first noticeable soon passes off.

In order to drain away the liquid, the contents of the stomach may be extended on an inclined plane and dried in the sun, or by some other suitable means.

This food is especially liked by draught-horses and swine. According to Gouin, it has the following percentage composition: nitrogenous substances 10.30 — fat 1.70 — carbohydrates 47 — fibre 31.90 — mineral substances 9.10.

The meat used to make soups and extract of meat and afterwards dried and reduced to powder had already been employed as a stock-feed or fertiliser many years before the war. During the war, however, the production of this meal must have been very limited since meat that had been used for making concentrated extracts was instead put into tins and sold for human consumption.

Meat meal is rich in highly digestible albuminoids and its low content of mineral salts is compensated for by other foods. Its average percentage composition is: dry matter 89 — albuminoids 72 — fat 13 — N-free extract 0.3 — ash 3.7.

To pigs it is fed mixed with the flour of grains rich in phosphate at the rate of 50-300 gm. per day. A little salt is added.

From bones, alimentary meals are made for cattle and poultry, they are sold under various names, such as pig meal and " pig compo ", products manufactured in Australia.

The *scrapings of hides* destined for the tanneries have always been used for glue and fertilisers, but during the war they were also used as fertilisers after they had been dried and ground. Their percentage is very variable: water 7.1-14.9 — nitrogenous substances 55.8-82 — fat 3.3-14.7 — ash 2.2-25.4 (KLING). These residues form a digestible food that can be given to all animals in place of protein feeds.

In Germany *bone-glue* dried and coarsely ground has also been used mixed with disintegrated horn scrapings (see p. 197).

When speaking of animal residues used as fertilisers, we shall treat of the manner in which *carcases* (see p. 246) are employed for this purpose. Here it may be mentioned that amongst the other methods adopted there is that of steaming under pressure which allows of the fat being separated and produces an excellent nutritious meal of about 18 % of the weight of the carcases treated. This is used like the bone-meal mentioned above.

37. — Fish Offals (1).

A fish-meal forming a stock-feed with a high albuminoid and phosphate content, but relatively poor in fat, is made from fish that are not used for human food and with the residues from tinning and salting factories viz. the heads, fins, tails, liver, intestines, etc. Of the albuminoids present fibrin is the chief, then albumin and collagene. The fat consists almost exclusively of stearine.

These substances are boiled to extract the oil and then dried and ground to powder.

Fish offals have long been used on a large scale in Germany. P. LABICHE says, " Germany has shown us that the future of the

(1) Cf. : 1) P. RAZOUS, *Les déchets et sous-produits industriels*. Paris, Dunod, 1921. — 2) P. LABICHE, *Contribution à l'effort économique de l'après-guerre. L'Utilisation des résidus de l'industrie de la pêche maritime et de la fabrication des conserves de poissons*. Paris, Dunod et Pinat, 1917. — 3) MARTINOLI Dr. C. *El valor de las harinas de pescado y de carne en el engorde de cerdos*. Buenos Aires, 1914. — 4) *Annales de la Soc. des Sciences Nat. de la Charente Inf.*, Nov. 1920. — 5) *The Journal of the Board of Agr.*, Vol. XXI, No. 7 and 8, Vol. XXIII No. 1. London, 1914-1916. — 6) *La Vie agricole et rurale*, Year X, Vol. XVIII, No. 10. Paris, 1921. — 7) *Agr. Journ. of India*, Vol. I, p. 4. Calcutta, 1914. — 8) *United States Dep. of Agr.*, Bull. No. 610. Washington 1917. — 9) J. M. BARTLETT. Fish wastes for feeding animals. *Thirty-third ann. Rep. of the Maine Agr. Exp. Stat.* Orono, 1917, p. 291. — 10) *Deutsche Landw. Pr.*, Year 48, Nos. 29 and 36. Berlin, 1921. — 11) POTT, E., op. cit., Vol. III, p. 672. — 12) KLING, Dr. MAX, op. cit., p. 172. — 13) GEO. MARTIN, Animal and Vegetable Oils, Fats and Waxes. London, 1920. — 14) GROWTHER, Fish Meals as a Food for Live Stock. *Jr. Board of Agr.*, XXVI, 1919. — 15) *The Farmer and Stockbreeder*, 18th Aug. 1910.

fishing industry lies in the utilisation of its by-products and residues ".

Fish meal (" fish guano ") contains on an average: 53 % protein — 6 % fat — 6 % organic matters — 8 % water — 27 % ash (lime, phosphoric acid and a little potash).

Over 90 % of the albuminoids are digestible. E. Dahl found the percentage of a French fish meal to be as follows: protein 60.02 — fat 9.65 — mineral substances 18.90 — water 14-40. Its digestibility was 90 %, and its nutritive value 72.9 %.

The chief countries producing these residues are North America, Sweden, Norway, Germany, England, France and Portugal.

In the large factory of Altona (Germany) the fish offal is sorted and then dried by hot air in a cylindrical dessicator that revolves horizontally. The dry residue contains 15-30 % of oil useful in various industries; it is extracted by means of petrol in large closed extractors. The oil-free residue is made into pig-meal.

In France, at Aytré near Rochelle, fish offal and rejected fish are dried in an autoclave without first extracting the oil. The product obtained is a fine powder of amber colour, with a strong smell of fish. It contains 55 to 60 % crude protein and 10 to 15 % calcic phosphate. It is fed to swine and poultry, but should not be given for one month before the animals are killed, as otherwise their meat has a slight fishy taste.

The fish not used for meal is made at the same factory into a powdered fertiliser containing: 3 to 4 % nitrogenous matter — 7-9 % phosphoric acid — and 2-3 % potash.

Large quantities of fish offal come from the fishing villages of Scotland and the East coast of England; these are used in the manufacture of: fish guano — fish meal for cattle — and fish oil.

The composition of fish meal is very variable, as is seen from the following figures quoted by Growther:

Moisture	7.7-18.1 %
Albuminoids (Protein)	51.1-63.1 (90 % digestible)
Oil	1.3-6.7
Ash	20.8-28.0
Common salt	0.6-5.3
Carbohydrates, Cellulose, etc.	0.3-4.2

This meal has a high food value, as is proved by the following figures: digestible protein 54 % — digestible oil 4 % — food units 145 — price of food unit (in 1919) 3 shillings.

Fish meal of inferior quality and a brown colour which is prepared from stale offal cannot be used as a stock-feed, but makes an excellent nitrogenous and phosphatic fertiliser ocntaining 8.03-9.59 % N, and 7.72-20.28 % of phosphates.

If the oil content of the meal exceeds 3 %, it may impart on unpleasant smell to milk and meat.

Taking it on the whole, the addition of 14 to 29 % of this meal to the basal ration increased the live-weight of pigs. The amounts to be fed according to the results of experiments made in Great Britain, Germany and Norway are : for cattle, 2 kg. per 1000 kg. live weight — for pigs ,110 to 225 gm. per head according to their live-weight — 100-200 gm. can be given to sheep — only 10 % may be added to the ration of adult fowls and 5 % to that of pullets. Fowls must be given fish-meal containing little fat and the birds must be accustomed to it gradually.

In France, farmers have reached the point of giving swine as much as 300 gm. of fish-meal a day, substituting it for an equal amount of other foods. The increased live-weight was obtained at less cost when this meal was fed. It also seems beneficial to piglings suffering from enteritis and osseous cachexy.

At Coimbatore (British India), an experiment was made with 10 cattle, 5 being fed a ration containing fish meal, and the other 5 receiving none. The amount of meal given was 340 gm. per head and per day. At the end of 6 weeks, the animals were quite accustomed to their new food, but their live-weight remained a little below that of the control lot, e. g. 6,804 kg. as against 6,849 kg. It appears that fish-meal promotes sexual maturity.

On the experimental farm of Leeds University and of the Yorkshire Council for Agricultural Education (England), experiments were conducted for 22 weeks with pigs which were given bran and shorts, gradually replaced by an equal weight of fish-meal. This produced an excess gain of 590 gm. in live-weight per head and per week during the first period, and of 635 gr. during the second period.

The manure of pigs thus fed fetched nearly three times as much per ton as that of the control animals. The use of fish-meal up to ½ of the total ration somewhat increased the cost per head per week. The meat and fat acquired no unpleasant smell.

At the Experiment Farm of the Bureaŭ of Animals Industry (United States) of the Washington Department of Agriculture, this meal was experimentally fed to 12 three-months-old Berkshire pigs. The lot fed fish-meal in addition to their ordinary rations increased 4.53 kg. more in live-weight than those given tankage as a supplement to the same ration.

The " Bezugsvereinigung Deutscher Landwirte G. m. b. H. " of Berlin has recently placed on the market a food called " Maismastfutter " which is composed of maize residues and fish-meal ; it has the following percentage composition : crude protein 18.3-20.8 — crude fat 5-6.2 — N-free extract 45.5-54.4 — fibre 5.4-9.

This food was given to fully grown swine at the rate of 2.3 lbs. (1. kg.) a day with 17.5 lbs. (8 kg.) of steamed, crushed potatoes, for 4 weeks, after which the quantity was increased to 4.4 lbs. (2 kg.) per head. The results were good, and the fish-meal had no deleterious effect upon the quality of the meat.

In Germany, on the initiative of the " Kriegsausschuss für Ersatzfutter " (War Commissariat for Forage Substitutes) a *meal* was made from dried, ground *mussels* which suited swine and fowls, especially if fed in small quantities (25 gm. per 100 kg. of live weight). Its percentage composition was as follows: water 1.7 — crude protein 10.6 (pure albumen 8.7) — crude fat 1.1 — N-free extracts 2.7 — crude fibre 0.8 — ash 83.1 (12 % sand and 1.6 % sodium chloride).

The small *lobsters* and *shrimps* from the North Sea were used in Germany for making an alimentary meal for swine and poultry. Their percentage composition is given in the following table.

	Dried lobsters	Dried shrimps
Water	15.9 %	9.3 %
Crude protein	52,9	56.3
Crude fat	3.9	5.0
N-free extracts	10.1	—
Crude fibre	—	—
Ash	17.6	18.6

38. — Dairy and Cheese Factories residues.

Spoilt milk. — A distinction must be drawn in this connection between the by-products and the residues. The by-products (casein, skimmed milk, whey, milk sugar, lactic acid) cannot be dealt with here.

We must however, consider *butter-milk* which has the following percentage composition: water 91 — fat 0.5 — casein and albumin 3.4 — lactose 4 — mineral substances 0.7. It is a true residue of butter-making.

Whey, like buttermilk, is good for pigs, provided it has not become altered by putrid fermentation which easily sets in.

Among the residues properly so-called is milk *spoilt* from various causes, which can nearly always be used for stock-feeding (1). If the alteration is due to contagious disease the milk must be boiled before use. Should putrid fermentation set in the milk must not be given to animals, but it can be used as liquid manure for watering dung and composts.

Cheese residues. — These are obtained by paring and scraping the cheeses when they are taken out of the forms; these residues are rich in nitrogenous substances and fat, and so, provided they are not too salt, they suit animals well.

They must naturally be given fresh and free from mould. These residues are soaked in water and used to moisten forages of inferior

(1) Cfr.: 1) A. Rolet, Les Industries annexes de la Laiterie, Paris, Baillière, 1920, p. 134. — 2) E. Pott, op. cit., Vol. III, p. 582.

quality. The amounts fed should be moderate. According to GOUIN, the following quantitites are injurious : 250-300 gm. for pigs ; 500 gm. for sheep ; 3-6 kg. for cattle.

39. — Disintegrated Hair and Horns.

Aiming at economy in the protein substances fed to sheep, N. ZUNTZ (1) conceived the idea of supplying the cystine (7.3 %) necessary for wool formation in the form of hair or other epithelial products rendered digestible by chemical treatment.

The experiment was made on two sheep taking all matter required for fleece formation from disintegrated horns ; the rest of the ratlon consisted of disintegrated straw and of swedes. The nitrogenous matter was furnished by 8-10 gm. of digestible horns per head and per day.

After 4 months the fleeces of these sheep were softer and the diameter of the staple was ⅓ larger than in the case of the control lot.

It would however appear that further experiment is necessary to prove that horns, even if subjected to special treatment, can be rendered digestible and nutritious. This opinion is confirmed by the results of recent experiments made at the Institute of Animal Physiology of the Berlin Academy of Agriculture (2).

In his experiments on sheep to which disintegrated, digestible horns were fed LEHMANN did not obtain a definite result and it was only in certain cases that any thickening of the fleece was observed. For this reason he rejects the favourable results obtained by HELLDORF. He does, however, allow that digestible horns may have a stimulating effect on wool production, but denies their having any food value.

Although it is premature to draw conclusions as to the value of these substances, LEHMANN states that when the rations of sheep are poor in concentrated foods, and their wool seems likely to be too fine, it might be well to thicken it by feeding 25 to 50 gm. of digestible, disintegrated horns per head and per day.

40. — Feathers.

During the moulting season, fowls need sulphur. Since feathers contain this substance in an organic form, poultry-breeders have been recommended to give their birds ground feather residues that have been dried on a sterilised oven (3). Each fowl should receive 1 gm. a day during moulting and ½ gm. afterwards.

It is however doubtful if the nutritive principles of this food are assimilable.

(1) *Biedermann's Zentralblatt*, Year XLIX, Part. 5, Liepzig, 1920.
(2) *Deutsche Landwirtschaftliche Zeitung*, Year XXV, No. 15. Hanover, 1921.
(3) Cfr. I. BILLITTERI, *Alimentazione gratuita*, etc. Palermo, 1921, p. 71.

41. — Chrysalids Silk-Worm Castings, Cockchafers larvae, etc. (1).

It is well known that during the reeling of the silk, the chrysalids remaining in the basins constitute annually a large mass of residue from which the fat can be extracted, and which serves as a stock-feed and fertiliser.

Every 100 kg. of raw, reeled silk corresponds to 110 kg. of dry chrysalids, so that the chrysalids represent about 79 % of the weight of the fresh cocoons. These chrysalids contain 16 to 18 % (and according to some authors much more) of an oil suitable for making ordinary soaps (see pag. 344).

The percentage composition of the entire chrysalids is: nitrogen 9-9.5 — phosphoric acid 1.7-1.8 — potash 1-1.1 — ash 5-5.5 — moisture 10-12. They thus make a good nitrogenous fertiliser.

Some people feed chrysalids to pigs, but they seem to give the meat an unpleasant smell and flavour. Chrysalids can also be given to poultry, and in Japan, they are fed very successfully to goats. When freed of fat, they contain 65 to 66 % protein of which about half is digestible.

Prof. G. Colombo, of the Milan "Laboratorio per studi ed esperienze sulla seta", has devised a process for making these chrysalids into a stock meal. They are first freed from fat, then treated with water rendered acid by sulphuric or hydrochloric acid, and finally dried and ground. This meal is given to cows, horses and rabbits. To the first it may be fed in a mash with a little salt and mixed with rice bran; in this form it is good substitute for linseed cake (see p. 152). The author found that 750 gm. chrysalid flour + 750 gm. rice flour were equivalent to 1 kg. of linseed cake. A little molasses renders the flour more appetising.

Prof. Colombo found that a better food product could be obtained if the chrysalids were not allowed to become altered by the beginning of decomposition before and after the treatment of the "ricotti". In order to keep them unchanged, they must be quickly dried in a current of hot air.

Silkworm castings are mixed with small fragments of leaves; they have long been used as a supplementary feed for cattle and pigs.

One ounce of silkworm eggs produces about 80 kg. of castings. The latter must only be fed in moderate quantities, for they have a strong absorbent capacity when introduced into the stomach of ani-

(1) Cf.: 1) Formenti, op. cit., p. 22. — Pirocchi A., in *L'Agric. Ital. Ill.*, Year 1, No. 2. Milan, 1919. — 3) Ruffoni. *Boll. del Cons. Prov. di Agric. di S. Michele*, Year XXXIII, No. 40, 1920. In Italy, the average annual supply of these chrysalids amounts to 6000 tons from which 900 to 1000 m. tons might be extracted, but as a matter of fact, less than half this quantity is obtained.

mals. They are kneaded in water and mixed with bran, beet roots, etc., before being given to cattle.

To horses, on the other hand, they are fed dry and preferably mixed with barley, or oats.

These castings are made into pig-wash and given to pigs which can eat as much as 1-1.5 kg. of the mixture per head and per day.

Certain *dead insects*, like locusts, that are generally used as manure (see p. 256), when dried and ground may be fed in small quantities to fowls, if mixed with bran mash.

Cockchafer grubs were readily eaten by fowls, but when the ration of these insects reached 30 gm. a day the hens' eggs had an unpleasant flavour. No doubt 5 to 10 gm. would be enough, for these larvae make a very concentrated food.

The grubs, which are very numerous in the soil some seasons, are generally collected, but the perfect insects, either entire or ground, can also be fed to poultry.

Fresh cockchafers contain on an average: 31.1 % dry matter — 20.9 % nitrogenous matter — 3.8 % crude fat — 4.8 % chitin (not digestible).

Fish (carp) eat whole cockchafers with avidity. *Cockchafer flour* is willingly eaten by swine, poultry fish and horses. It can be fed mixed into a paste with equal quantities of bran.

The larvae of *Tenebrio molitor* and those of various species of fly can also be given to fish.

Chopped-up earthworms are much liked by trout, and also by poultry if mixed with bread, barley, boiled potatoes, etc.

42. — Synthetic Albumen of fermentation.

Mr. HAYDUCK (1) has devised a process for obtaining synthetic albumen by means of a special aerobic ferment sown on a solution of sugar and ammonium sulphate. After 5 hours fermentation albumen is produced.

The studies have been carried out at the "Institut für Gärungsgewerbe" in Berlin.

Instead of commercial sugar, the author proposes using the waste waters of sugar-refineries and starch factories containing at least 0.75 % of sugar, or else molasses.

From 100 parts of sugar can be obtained 76 kg. of dry matter containing 50 % albumen. It was suggested using this dry material as a stock feed. The chemical composition of this mineral yeast is as follows:

(1) Cf.: 1) *Die Deutsche Zuckerindustrie* No. 39. Berlin, 1915. — 2) Dr. MAX KLING, op. cit., p. 140.

	According to W. WÖLTZ	According to D. MEYER
Water	5.9 %	11.5 %
Crude protein	52.6	45.1
Crude fat	5.8	—
N-free substances	24.6	25.1
Mineral substances	11.1	18.3

The starch value, according to D. MEYER, is 56.9 kg. This yeast has the same food value as dried beer-yeast.

It has given good results when tried on cows and swine. The production cost of 100 kg. of this albumen has been estimated by HAYDUCK at 25 *marks* in the case of factories with an annual output of 10.000 tons of dried food. This figure appears to us very low.

In conclusion, we believe that it is a question of giving this ferment the means of multiplying and producing in its organism, after the manner of the ferments, albuminoid substances at the expense of the carbon, hydrogen and oxygen in the sugar and the nitrogen of thé ammonium sulphate.

In Germany, during the War, nutritive yeasts of various qualities were produced in considerable quantities (see p. 61), but this was one of the many quasi industrial processes which came to an end with the cessation of hostilities.

43. — Synthetic Fat of fermentation.

At the Berlin "Institut für Gärungsgewerbe", a new ferment was isolated that was capable of producing a thick layer of fat in a special liquid (?). This layer, on drying, had the following percentage composition: ash 8.8 — organic matter 91.9 — crude protein 31.4 — fat 17.06 — carbohydrates 43.44. The fat was a saponifiable oil and, in view of the dearth of fats in Germany during the war, was recommended as a stock-feed (1).

In order to judge whether this discovery is an accredited fact of any value, two important points need to be ascertained: the yield of the industrial process and the digestibility coefficient of the products.

(1) Cf. *Tageszeitung für Brauerei*, Year 13, No. 236, Berlin, 1915.

44. — Composition, digestibility and Starch Value of Feeds (*after O. Kellner*).

NATURE OF THE FEEDS (*Waste products*)	CRUDE PERCENTAGE COMPOSITION								ELEMENTS nutritivs digestibles				AVAILABILITY (Full availability = 100)	DIGESTIBLE ALBUMIN	STARCH VALUE for 100 kilos
	Dry matter	Crude albumin	Crude fat	N-free extracts	Crude fibre	Ash	Phosphoric acid	Lime	Crude albumin	Crude fat	N-free extracts	Crude fibre			
GREEN FORAGE															
Leaves and haulms															
Fodder cabbage	15.3	2.5	0.7	8.1	2.4	1.6	»	»	1.8	0.4	6.5	1.7	94	1.2	9.4
Potato haulms — July and August	15.0	3.6	0.7	6.2	3.0	1.5	»	»	2.0	0.2	3.8	1.3	86	0.9	5.5
Potato haulms before harvest	23.0	2.5	1.0	10.2	6.2	3.1	»	»	1.1	0.2	6.1	2.2	78	0.6	7.2
Leaves of cabbage turnip	13.5	2.8	0.4	7.1	1.6	1.6	0.23	0.75	1.9	0.2	5.7	0.9	93	0.4	6.3
Leaves of Swede turnip	11.6	2.2	0.5	5.3	1.5	2.1	0.10	0.44	1.5	0.2	4.2	0.8	93	0.4	5.3
Carrot leaves	18.2	3.4	0.9	7.1	2.5	4.3	0.10	1.30	2.2	0.5	4.7	1.4	91	1.5	7.8
Fodder beet leaves	11.0	2.4	0.4	4.6	1.6	2.0	0.09	0.18	1.6	0.2	3.5	0.9	92	1.0	5.3
Jerusalem artichoke leaves	32.3	3.4	1.1	17.4	5.4	5.0	0.04	0.30	2.0	0.5	13.1	2.2	91	1.7	16.2
White cabbage	10.0	1.7	0.3	5.0	1.8	1.2	0.13	0.15	1.2	0.1	3.8	1.3	91	0.7	5.4
Leaves and collars of sugar beet	16.2	2.3	0.4	7.4	1.6	4.8	0.08	0.17	1.7	0.2	5.9	1.1	84	1.4	7.2
Leaves of birch, August	45.0	7.9	3.9	24.7	6.9	1.6	»	»	4.8	2.5	16.3	3.7	91	3.9	26.0
Leaves of beech, August and September	43.0	6.9	1.5	21.7	9.8	3.1	»	»	4.2	0.8	14.3	4.4	82	3.4	19.2
Leaves and stalks of hop	34.0	4.7	1.3	14.7	9.2	4.1	»	»	3.0	0.8	9.4	3.8	83	2.4	18.7
Twigs in winter	75.0	4.6	1.9	40.3	26.7	1.5	»	»	2.1	0.8	20.2	6.7	49	1.6	14.5
» in spring	70.0	2.6	1.4	36.2	28.2	1.6	»	»	1.2	0.6	18.1	7.1	40	0.8	10.8
» of poplar, July	76.4	6.0	2.6	34.4	30.4	3.0	»	»	2.3	1.1	17.5	8.2	40	1.7	11.9
DRY															
Leaves, haulms, etc.															
Nettle	88.6	18.3	7.7	38.0	10.6	14.0	0.94	3.39	12.8	4.9	30.0	6.0	89	9.3	48.0
Leaves and stems of hop	89.4	12.5	3.5	38.1	24.5	10.8	»	»	8.0	2.5	27.1	7.6	69	6.1	31.1
Potato haulms	90.0	9.4	2.4	40.6	26.0	11.6	»	»	3.8	0.6	24.4	9.6	68	2.3	25.3
Leaves of deciduous trees, end of July	84.0	10.5	3.0	49.3	14.2	7.0	»	»	6.2	2.4	32.5	5.3	82	3.7	37.7
Poplar leaves, October	84.0	10.8	8.7	39.6	17.4	7.5	»	»	6.0	6.9	26.2	5.6	73	3.4	26.7
Vine-leaves, autumn	88.0	11.4	5.7	52.9	8.0	10.0	»	»	6.7	4.5	34.4	3.0	90	4.1	42.5
Winter twigs, acacia	87.6	9.8	1.7	41.0	31.5	3.6	»	»	5.5	0.6	19.3	6.6	41	4.0	12.6
» » beech	84.7	4.0	1.6	38.0	38.5	2.6	»	»	0.6	0.2	6.1	2.7	−139	0.1	−12.9
Twigs gathered July, poplar	86.4	6.7	2.9	39.1	34.4	3.3	»	»	2.6	1.1	19.9	9.4	40	1.8	13.2
Pine sawdust	83.5	0.3	0.7	19.6	62.4	0.5	»	»	»	»	7.8	6.9	− 22	»	− 3.3
Jerusalem artichoke tops	87.5	12.7	2.2	48.1	14.2	10.3	»	»	7.6	1.1	33.6	4.1	82	6.1	37.3
Elm leaves	88.0	15.9	2.9	49.9	8.6	10.7	»	»	11.6	0.7	40.7	4.9	91	8.5	50.0
Dried sugar beet leaves and collars	86.0	9.1	0.8	34.8	11.1	30.2	»	»	3.7	0.2	28.5	7.4	82	1.7	27.7

NATURE OF THE FEEDS (*Waste products*)	CRUDE PERCENTAGE COMPOSITION								ELEMENTS nutritivs digestibles				AVAILABILITY (full availability = 100)	DIGESTIBLE ALBUMIN	STARCH VALUE for 100 kilos
	Dry matter	Crude albumin	Crude fat	N-free extracts	Crude fibre	Ash	Phosphoric acid	Lime	Crude albumin	Crude fat	N-free extracts	Crude fibre			
STRAWS															
Cereal straws.															
Winter spelt.	85.7	2.7	1.4	31.8	44.0	5.8	0.16	0.29	0.8	0.4	22.0	11.8	28	0.6	9.7
Spring barley	85.7	3.5	1.4	35.9	39.5	5.4	0.18	0.43	0.9	0.5	19.0	21.3	46	0.6	19.0
Barley with clover	85.7	6.5	2.0	38.0	33.4	5.8	»	»	3.2	1.0	20.9	18.4	56	2.4	24.2
Winter barley	85.7	3.2	1.4	33.5	42.0	5.6	0.18	0.50	0.7	0.4	12.7	21.0	31	0.5	10.7
» oats	85.7	3.8	1.6	35.9	38.7	5.7	0.15	0.43	1.3	0.5	16.5	20.9	43	1.0	17.0
Millet	85.0	4.8	2.3	36.4	35.2	6.3	»	»	1.6	1.1	20.0	19.4	52	1.2	22.3
Maize	85.0	5.0	1.5	34.5	39.2	4.8	0.30	0.49	1.7	0.5	17.2	23.5	47	1.3	20.5
Rice	86.8	5.5	2.2	33.5	35.3	10.3	»	»	2.5	1.0	10.7	20.1	40	1.2	13.0
Spring cereals average . . .	85.7	3.7	1.4	37.5	39.0	4.1	»	»	1.2	0.4	18.5	21.1	46	1.0	18.8
» » best quality .	85.7	6.5	2.3	34.0	36.4	6.5	»	»	2.6	0.8	17.5	20.6	50	2.2	20.7
Winter Rye	85.7	3.1	1.3	33.2	44.0	4.1	0.28	0.31	0.6	0.4	12.9	22.0	30	0.4	10.6
Wheat	85.7	3.0	1.2	35.9	40.8	4.8	0.20	0.27	0.2	0.4	13.3	20.4	32	»	10.9
Winter cereals, average . . .	85.7	3.0	1.2	34.6	42.2	4.7	»	»	0.2	0.4	13.1	22.0	32	»	11.5
» » best quality.	85.7	4.8	1.4	35.8	38.3	5.4	»	»	0.8	0.5	16.1	21.4	43	0.4	16.7
Leguminous straws.															
Garden bean	81.6	8.1	1.1	31.0	36.0	5.4	0.22	1.16	4.0	0.5	20.5	15.5	48	3.2	19.2
Peas	86.4	9.0	1.6	33.7	35.5	6.6	0.36	1.65	4.3	0.7	18.5	13.7	44	3.4	16.2
Fodder vetch	86.7	9.0	1.7	29.8	40.9	5.3	0.27	1.56	4.1	0.8	15.4	16.4	35	3.2	12.7
Leguminous straw, average. .	84.0	8.0	1.0	32.5	38.0	4.5	»	»	3.8	0.4	18.2	15.4	41	3.0	15.2
» » best quality	84.0	10.2	1.2	33.0	34.5	5.1	»	»	5.0	0.5	19.5	15.0	49	3.8	19.1
Lentils	84.0	13.9	1.7	28.1	33.6	6.7	»	»	6.8	0.8	16.8	13.7	46	4.0	16.4
Lupin.	84.0	6.5	1.4	30.8	41.4	3.9	0.25	0.97	2.5	0.4	20.0	21.0	45	1.6	19.4
Red clover	84.0	9.1	1.8	22.8	44.6	5.7	»	»	4.0	0.6	11.1	16.4	18	3.1	5.8
Velvet vetch	84.0	6.7	1.2	32.1	39.9	4.1	»	»	2.8	0.4	16.2	15.5	33	2.1	11.4
Soya bean	84.0	7.4	2.0	38.3	26.1	10.2	0.30	1.43	3.7	1.2	25.3	9.9	52	3.0	16.2
Wood vetch	85.2	13.1	1.7	29.0	37.0	4.4	»	»	8.7	0.8	15.0	11.0	37	7.0	12.7
Other straws.															
Buckwheat	84.0	4.8	1.2	34.6	38.2	5.2	0.61	0.95	2.2	0.5	18.0	17.2	42	1.7	15.7
Poppy	84.0	6.1	1.4	33.9	33.9	8.7	0.16	1.47	2.8	0.6	18.4	15.2	47	2.2	17.2
Colza	84.0	2.5	1.2	38.7	37.8	3.8	0.25	1.17	1.0	0.5	20.4	14.0	42	0.7	15.2
Ground seed-beet.	84.0	5.5	0.9	32.8	36.2	»	»	»	1.2	0.3	13.5	9.0	56	1.2	13.7
HUSKS AND CHAFF															
Cereals.															
Dari	94.3	3.9	0.9	55.7	25.8	8.0	»	»	1.5	0.4	33.4	12.9	85	1.1	40.7
Spelt	85.7	3.5	1.3	32.6	40.0	8.3	0.59	0.20	1.1	0.4	13.9	20.0	67	0.7	23.8

NATURE OF THE FEEDS *Waste products*	CRUDE PERCENTAGE COMPOSITION: Dry matter	Crude albumin	Crude fat	N-free extracts	Crude fibre	Ash	Phosphoric acid	Lime	ELEMENTS nutritivs digestibles: Crude albumin	Crude fat	N-free extracts	Crude fibre	AVAILABILITY (Full availability : = 100)	DIGESTIBLE ALBUMIN	STARCH VALUE for 100 kilos
Barley	85.5	2.9	1.5	38.4	29.9	12.8	»	»	0.8	0.5	17.3	14.4	74	0.5	24.5
Oats	86.2	5.0	2.5	41.5	26.7	10.5	0.13	0.40	1.9	0.8	19.9	13.6	79	1.4	28.6
Millet	88.0	4.8	2.2	29.0	40.8	11.2	»	»	1.7	0.7	13.6	15.1	62	1.2	19.4
Maize stripped stalks	86.9	3.5	0.9	41.3	38.9	2.3	0.02	0.02	1.6	0.4	22.2	19.5	49	1.2	21.1
Rice	90.0	3.7	1.4	32.3	38.1	14.5	0.17	0.09	0.4	0.9	11.3	0.4	19	0.1	2.5
Rye	85.7	3.5	1.3	29.1	44.1	7.7	0.56	0.35	1.1	0.4	11.3	22.0	63	0.7	22.0
Wheat	84.0	4.7	1.7	37.1	30.4	10.1	0.40	0.17	1.4	0.5	16.7	14.6	74	0.9	24.3
Leguminous.															
Garden beans	85.0	10.7	2.0	32.5	33.5	6.3	0.27	0.68	5.2	1.0	21.1	14.4	53	4.0	21.8
Peas	86.0	9.8	1.2	33.7	35.4	5.9	»	»	4.9	0.5	20.2	15.9	50	3.7	20.1
Groundnut pods crushed	89.9	7.2	2.9	18.5	59.1	2.2	0.17	0.81	2.6	2.8	7.2	2.0	1	2.1	0.1
Lentils	85.0	13.8	1.8	38.4	19.5	7.0	»	»	10.1	1.0	22.2	9.6	73	8.3	30.3
Lupin	85.0	6.8	0.7	41.5	30.1	5.9	0.10	0.44	2.6	0.2	25.3	14.4	45	1.8	14.4
Soya bean	88.0	6.3	1.5	42.0	30.1	8.1	»	»	2.8	0.8	30.7	15.3	65	2.0	32.0
Vetch	85.0	10.4	2.2	31.8	32.3	8.3	»	»	5.1	1.1	19.1	13.9	52	3.9	20.1
Other plants.															
Buchwheat	86.8	4.6	1.1	35.4	43.5	2.2	»	»	2.1	0.5	14.8	13.1	59	1.6	17.8
Cacao hulls, meal	90.0	14.3	6.2	46.3	15.8	7.4	»	»	0.6	5.2	22.3	3.3	88	»	33.6
Linseed	88.4	3.5	3.4	35.0	40.7	5.8	0.45	1.56	1.4	1.7	13.0	12.2	60	1.0	17.7
Camelina	88.8	2.7	1.1	32.6	45.2	7.2	0.15	1.60	1.0	0.4	12.1	13.6	52	0.7	14.1
Colza	84.0	3.5	1.6	34.4	37.4	7.1	0.36	3.44	1.5	0.7	16.6	15.3	37	1.1	12.7
Rape	84.8	3.5	1.5	34.3	37.7	7.8	»	»	1.5	0.6	16.5	15.5	36	1.1	12.4
Sugarbeet seed waste, ground	84.0	12.6	1.8	33.4	26.7	»	»	»	7.2	1.2	15.0	4.5	71	5.1	18.8
INDUSTRIAL WASTE PRODUCTS															
Milling.															
Cotton seed hulls	88.5	3.5	1.3	39.3	40.7	»	»	»	0.2	0.8	19.6	17.5	77	»	29.7
Coarse buckwheat bran	84.4	8.0	1.8	34.2	37.6	2.8	1.01	0.23	4.8	1.2	20.9	9.4	70	4.3	25.8
Fine » »	88.0	15.2	4.5	50.0	11.3	7.0	»	»	11.4	3.4	39.0	3.7	94	9.9	55.2
Spelt bran	87.8	15.1	4.3	52.5	10.0	5.9	»	»	11.8	3.8	44.1	2.5	95	10.3	60.7
Pea pods	88.0	7.3	1.2	31.9	44.7	2.9	»	»	5.1	0.9	28.6	42.2	83	4.7	64.1
Pea bran	88.3	16.8	1.7	46.2	20.1	3.5	»	»	12.6	1.2	42.5	16.1	92	11.3	65.7
Pea flour (fodder)	86.5	23.4	2.0	51.0	7.0	3.1	»	»	21.1	1.4	48.4	4.9	97	18.4	71.3
Groundnut hulls	89.9	7.2	2.9	18.5	59.1	2.2	»	»	2.6	2.8	7.2	2.0	1	2.1	0.1
Groundnut bran	89.5	21.8	18.1	24.7	19.5	5.4	»	»	16.3	16.3	16.0	9.7	93	15.3	73.7
Barley bran	89.5	14.8	3.6	57.6	8.5	5.0	0.92	0.19	12.5	3.1	49.5	1.7	96	11.4	66.0
Oat chaff	86.0	1.9	0.5	45.8	32.4	5.5	0.16	0.14	»	0.2	16.5	10.7	66	»	18.3
Oat bran	90.4	7.6	2.7	53.8	21.6	5.7	»	»	3.8	1.5	37.5	8.0	88	3.4	45.3

NATURE OF THE FEEDS (*Waste products*)	CRUDE PERCENTAGE COMPOSITION: Dry matter	Crude albumins	Crude fat	N-free extracts	Crude fibre	Ash	Phosphoric acid	Lime	ELEMENTS nutritivs digestibles: Crude albumin	N-free extracts	Crude fat	Crude fibre	AVAILABILITY (Full availability : = 100)	DIGESTIBLE ALBUMIN	STARCH VALUE for 100 kilos
Millet chaff	88.4	3.9	1.2	27.9	45.9	9.5	»	»	0.8	»	3.0	1.9	-116	0.4	- 6.6
Millet polishings	90.6	16.5	15.3	43.5	8.5	6.8	»	»	13.2	14.5	34.8	2.3	97	11.2	80.1
Rye bran, average	87.5	16.7	3.1	58.0	5.2	4.5	2.44	0.18	12.5	2.4	42.9	1.7	79	10.8	46.9
Wheat bran, fine	87.8	15.5	4.8	54.0	8.0	4.5	2.25	0.14	12.9	3.7	40.5	2.1	79	11.1	48.1
» » coarse	87.8	14.3	4.2	52.2	10.2	5.9	»	»	11.3	3.0	37.1	2.6	77	9.8	42.6
Starch manufacture.															
Fresh potato pulp	14.0	0.6	»	11.5	1.5	0.4	0.03	0.05	»	»	8.8	0.2	95	»	8.6
Dried » »	86.0	3.4	0.1	68.2	8.8	5.5	»	»	»	»	52.5	1.1	95	»	50.9
Dried gluten	90.0	76.2	5.1	6.2	0.4	2.1	»	»	72.4	4.3	4.3	0.1	100	71.7	80.9
Fresh maize residues	24.8	3.6	1.6	16.6	2.8	0.2	»	»	2.9	1.4	15.1	1.4	92	2.2	19.5
Dried » »	87.2	14.0	5.7	61.3	4.3	1.9	»	»	11.9	5.1	55.8	2.3	90	10.7	71.1
Maizena	91.9	23.7	2.5	56.8	6.8	2.1	»	»	20.1	1.5	46.6	3.6	90	18.6	63.8
Fresh rice offal	44.7	13.6	1.1	28.7	0.6	0.7	»	»	11.2	0.6	26.1	0.4	92	8.5	32.8
Dried »	86.0	26.2	2.1	55.2	1.1	1.4	»	»	21.5	1.0	50.3	0.7	90	16.3	61.4
Wheat chaff	25.5	4.0	1.8	15.2	3.8	0.7	»	»	3.0	1.4	12.6	1.9	77	2.4	15.0
Fresh wheat residues	15.4	2.0	0.9	10.5	1.6	0.4	»	»	1.6	0.5	9.0	0.8	90	1.2	10.7
Dried » »	87.1	8.7	1.7	74.6	0.8	1.3	»	»	6.7	0.9	65.7	0.5	88	5.6	64.4
Sugar refining.															
Fresh pulp or slices	7.0	0.6	»	4.7	1.4	0.3	0.03	0.15	0.3	»	4.0	1.0	94	0.3	5.0
Pressed » »	15.0	1.3	0.1	9.9	3.0	0.7	»	»	0.7	»	8.5	2.2	94	0.6	10.6
Acid ensilage	11.6	1.0	0.2	7.2	2.3	0.9	»	»	0.5	0.1	5.4	1.2	90	0.3	6.5
Dried »	88.8	8.1	0.6	58.5	17.6	4.0	0.15	1.40	4.1	»	50.4	12.7	78	3.6	51.9
Ordinary molasses	78.1	10.5	»	60.4	»	7.2	0.05	0.31	5.4	»	54.9	»	87	»	48.0
Pulp with molasses	90.0	8.7	0.3	60.8	13.8	6.4	»	»	4.6	»	52.0	8.2	81	2.7	50.5
Beet slices sweetened	91.4	7.1	0.4	67.9	11.8	4.2	»	»	4.3	»	63.8	9.0	77	3.5	58.9
Brewing, Distilling etc.															
Brewers' grains fresh	23.8	5.1	1.7	10.6	5.1	1.2	0.39	0.15	3.7	1.5	6.6	2.0	86	3.5	12.7
» » dried	91.0	21.2	7.5	41.7	16.0	4.6	»	»	15.1	6.6	25.0	7.7	84	14.1	50.3
American grains	91.0	26.5	7.0	42.1	12.5	2.9	»	»	20.0	6.0	25.3	6.0	87	18.8	53.7
Dried distillers' grains	92.2	19.5	7.2	48.3	14.6	3.2	»	»	13.8	6.3	29.9	7.0	84	12.9	51.3
Dried cereal lees	92.5	23.5	7.5	41.5	13.4	6.6	»	»	15.0	7.0	33.2	6.7	84	12.2	54.4
Exhausted hops	89.1	15.3	6.8	39.6	21.0	6.4	»	»	4.7	4.4	19.0	3.6	83	3.0	28.7
» yeast residues	87.9	49.3	2.9	30.4	0.1	5.2	»	»	42.7	1.1	24.8	»	100	40.5	65.0
Potato lees fresh	5.7	1.2	0.1	3.1	0.6	0.7	0.13	0.03	0.6	»	2.2	0.1	93	0.5	2.6
» dried	90.0	24.3	3.7	40.8	9.5	11.7	»	»	12.2	1.8	20.4	2.0	90	9.4	31.2

(*) The crude albumin of molasses consist entirely in non albuminoid subtances.

NATURE OF THE FEEDS (*Waste products*)	CRUDE PERCENTAGE COMPOSITION								ELEMENTS nutritivs digestible.				AVAILABILITY (Full availability : = 100)	DIGESTIBLE ALBUMIN	STARCH VALUE for 100 kilos
	Dry matter	Crude albumin	Crude fat	N-free extracts	Crude fibre	Ash	Phosphoric acid	Lime	Crude albumin	Crude fat	Crude fibre	N-free extracts			
Maize lees fresh	8.7	2.0	0.9	4.5	0.8	0.5	0.14	0.03	1.3	0.8	3.2	0.4	90	1.1	5.5
» dried, light	91.4	31.8	12.8	35.8	9.0	2.0	»	»	21.3	12.2	25.4	6.3	88	12,7	65.3
» » dark. . . .	92.0	27.0	10.0	39.1	8.6	7.3	»	»	16.2	9.3	25.4	5.1	86	13.1	53.8
Green malt	52.0	6.5	1.2	38.1	4.8	1.4	0.53	0.05	5.2	1.1	33.1	2.4	96	3.9	39.9
Dried malt	92.5	9.5	2.5	69.1	9.0	2.4	0.93	0.10	7.6	1.9	60.1	4.5	96	5.7	71.0
Malt germs	88.0	23.1	1.5	43.6	12.3	7.5	1.73	0.18	18.5	1.1	31.8	6.8	75	11.4	38.7
Molasses lees.	7.8	1.9	»	4.0	»	1.9	0.01	0.01	1.0	»	3.6	»	95	0.3	3.7
Rye lees fresh	7.8	1.7	0.4	4.6	0.7	0.4	»	»	1.1	0.3	3.7	0.4	87	0.9	4.8
» » dried	90.0	22.7	5.4	47.1	8.9	5.9	»	»	14.5	4.9	37.7	5.3	84	11.9	53.2
Apple lees fresh	19.8	0.9	0.7	13.2	4.5	0.7	»	»	0.4	0.3	9.2	0.3	92	0.3	9.5
» » dried	90.0	4.0	3.2	50.1	20.5	3.2	»	»	1.6	1.6	41.4	1.3	78	1.2	36.6
Grape lees with stalks — fresh . . .	30.0	3.4	2.4	11.9	9.4	2.9	»	»	0.5	1.3	4.3	0.8	32	0.3	2.5
Grape lees with stalks — dry. . . .	90.0	10.5	7.3	36.1	28.2	7.9	»	»	1.6	4.0	13.0	2.1	32	1.1	7.5
ANIMAL PRODUCTS.															
Blood meal	91.0	83.9	2.5	»	»	4.2	»	»	77.2	2.0	»	»	100	68.0	67.7
Greaves	90.5	58.6	25.5	»	»	6.4	»	»	55.7	23.5	»	»	100	52.7	106.1
Fish meal, poor in fat . . .	87.2	52.5	2.1	»	»	32.6	»	»	47.3	1.6	»	»	100	43.6	44.0
» » rich in fat. . . .	89.2	48.4	11.6	»	»	29.2	»	»	43.6	11.0	»	»	100	40.1	64.2
Forage meat meal	89.2	72.3	13.2	»	»	3.8	0.69	0.36	67.2	12.5	»	»	100	63.6	89.9
Knackers' yard meal	93.0	50.3	17.0	1.0	2.7	22.0	»	»	39.2	16.2	»	»	»	24.1	70.3
Skimmed milk	10.2	4.0	0.8	4.6	»	0.8	0.26	0.19	3.8	0.8	4.6	»	100	3.8	9.0
Separated milk	9.7	4.0	0.2	4.7	»	0.8	»	»	3.8	0.2	4.7	»	100	3.8	7.6
Butter milk	9.9	4.0	1.1	4.0	»	0.7	»	»	3.8	1.1	4.0	»	100	3.8	9.2
					Chitine										
Cockchafers fresh	31.1	20.9	3.8	»	4.8	1.6	0.59	0.04	14.4	3.1	»	»	100	12.4	19.1
dried	85.6	57.6	10.5	»	13.1	4.5	»	»	39.7	8.7	»	»	100	34.0	52.9
Sweet whey	7.3	1.0	0.8	4.9	»	0.6	0.09	0.10	0.9	0.8	4.9	»	100	0.9	6.4
Sour »	6.9	1.0	0.2	4.9	»	0.8	»	»	0.9	0.2	4.9	»	100	0.9	5.0
Whale meal	92.7	62.3	25.1	»	»	4.8	»	»	56.1	23.8	»	»	100	47.1	101.6
» » rich in bone . .	94.4	51.1	21.9	»	»	19.2	»	»	46.0	20.8	»	»	100	38.6	86.4

III. — FERTILISERS.

The utilisation of waste material and residues as fertilisers, will probably suggest in the first instance household and other refuse, animal and human excrements, offals from slaughterhouses and fisheries, and other organic matter long used for fertilising the soil. But there are many other materials which the war obliged farmers and manufactures to utilise, materials before 1914 little and only locally employed or even entirely neglected because they were considered of no value.

The great scarcity of all kinds of raw material and consequently also of fertilisers, experienced in all countries during the war, made investigators realise that the waste of immense quantities of refuse meant a certain loss to agriculture of large amounts of nitrogen, phosphoric acid and potash. In these very substances the cultivated soils were all the time becoming poorer owing to the diminishing production of chemical fertilisers. Enquiry was then made into the best means of remedying this state of affairs, at least partially, and a more systematic and wider use of refuse of all kinds was inaugurated. Many new avenues were opened and others which had been abandoned for very many years were again explored. Experiments were hurriedly made with processes directly converting certain residues into fertiliser, or extracting from others, unsuitable for direct use, the fertilising matter contained in them: industrial application soon followed.

Thus the process was intensified of extracting potash from the algae which are cast up by the sea on certain coasts or which the sea contains in quantities near the shore.

Processes of purification of sewage water or of utilisation of their sediments were improved and extended; the conversion of straw directly into manure was enquired into; the potassic dust from cement kilns and the refuse from blast furnaces became appreciable sources of potash for the soil; attempts were again made to extract potash from the brine of salt-works, and ashes of all kinds were carefully collected and utilised.

The waste from several industries was treated with a view to its use as fertiliser without considering too closely the cost, often so high that once the war was over economic reasons prevented the application of many of the processes.

But while in certain cases this utilisation of waste material brought about by the war came to an end with the advent of peace, in other cases it remains and will continue as something of definite value arising from amongst the numerous disasters engendered by the terrible conflict.

In this part of the book, an attempt is made to set out in a brief but adequate manner everything relating to the utilisation of residues from large and small industries, from households or from public economy, the aim being to make clear, as may appear necessary, not only the general lines of each topic but the special action taken during the war in relation to the question of fertilisation of the soil.

1. — Seaweed or Kelp: its use as a potassic or other fertilising product (1).

Seaweed is used in various countries, either directly as a fertiliser, or for the potash that can be obtained from the ash. Professor I. GIGLIOLI (2) writes: " instead of digging in a green crop which besides the expense of the seed and labour costs as least the rent of the land for the period of growth, it is better to dig in seaweed, whenever possible: these cost only the expense of gathering up on the shore and carting to the fields. In the neighbourhood of the coast digging in seaweed will always be less costly than manuring with leguminosae: and when it is done with seaweed properly handled, it will entail equally good results with a cereal crop. "

(1) Cf.: 1) *American Machinist*, Vol. 47, No. 14, London, 1917. — 2) UNITED STATES DEP. OF AGRIC. *Office of the Secret. Report* 100, Washington, 1915. — 3) *Engineering and Mining Journal*, Vol. CII, No. 25, New York, 1916. — 4) TURRENTINE, J. W., *Bull. of the U. S. Dep. of Agric.*, No. 150, Washington, 1915. — 5) HOAGLAND, D. R. and STEWART, G. K., *Journal of Agric. Res.*, Vol. IV, Washington, 1915. — 6) PETHYBRIDGE, G. H., *Dep. of Agric. and Techn. Instruction for Ireland, Journal*, Vol. XV, No. 3, Dublin, 1915. — 7) GLOESS, P., *Moniteur Scientifique du Dr. Quesneville*, year LX, Vol. VI, parts I and II, Paris, 1916; year LX, Vol. X, Nos. 936 and 945, Paris, 1920. — 8) HENDRICK, J., *Journal of the Society of Chem. Ind.*, vol. XXXV, No. 10, London, 1916. — 9) TROTTER, A., *Flora economica della Libia*, Rome, Tip. Unione Editr., 1915. — 10) SESTINI, F., Analisi chimica d'una pianta marina, in *Le Staz. Sperimentali Agr. It.*, Vol. III, 1874, p. 115; Vol. IV, 1875, p. 48; vol. V, 1876, p. 102. — MUSSO, G., Sulla composizione della *Posidonia caulini*, *Ibidem*, Vol. IX, 1880, p. 189. — 11) READ, J. and SMITH, H. G., An Investigation of the « Marine fibre » of *Posidonia australis*, *Comm. of Australia. Institute of Science and Industry, Bull.* No. 14. Melbourne 1919. — 12) J. W. TURRENTINE and P. S. SHOAFF, Potash from Kelp, in *The Journal of Industrial and Engineering Chemistry*, No. 11, 1919; No. 12, 1920; No. 13, 1921; No. 14, 1922; No. 2, 1923. New York — 13) TH. H. NORTON, Potash production in California and Potash from Kelp. *Dep. of Comm.* Washington, 1915. — 14) K. YENDO, Sapporo. On the Cultivation of Seaweeds, with special accounts of their ecology. *The Economic Proceeding, Royal Dublin Society*, Vol. II, No. 7. Dublin, March 1914. — 15) BURD, S. J., The Economic Value of Pacific Coast Kelps. *Coll. of Agric., Agric. Exp. St. Bull.*, No. 248, 1915, Berkeley, Cal. — 16) FR. K. CAMERON, Kelp and other sources of potash. *Journal of the Franklin Inst.* Philadelphia, Pa., Oct. 1913. — 17) U. S. DEP. OF AGRIC., *Yearbook* 1915, 1916, 1917, 1918, 1919, 1920. — 18) U. S. GEOLOG. SURVEY, Potash in 1920. Washington, Gov. Pr. Off., 1921. — 19) E. SOREL, La grande industrie chimique minérale. Paris, 1904, Vol. 2, p. 124. — 20) UNIV. OF CALIFORNIA, The Marine Algae of the Pacific Coast of North America. *Univ. Cal. Press.* Berkeley, 1919-20. — 21) SIDNEY J. JOHNSTONE, *Potash*, Imper. Instit. London, 1922.

(2) I. GIGLIOLI, Campo sperimentale di Suessola. Cultura del frumento. Portici, 1901, p. XI.

During the war, as potassic salts were no longer imported from Germany there was a considerable development of the extraction of potash from seaweeds, especially in the United States where, as we shall see later, large quantities of certain species of seaweeds, very rich in potash (1), are found.

In the United States the collection of seaweed is carried on by several companies along the Pacific coast from Los Angeles to San Diego. It is done by means of large barges provided with a special elevator loading apparatus with blade-bearing bar like that of reaping machines (see fig. 57).

Ordinarily seaweeds are collected to a depth of 6-8 feet, for below that depth they are less rich in potash. These barges can

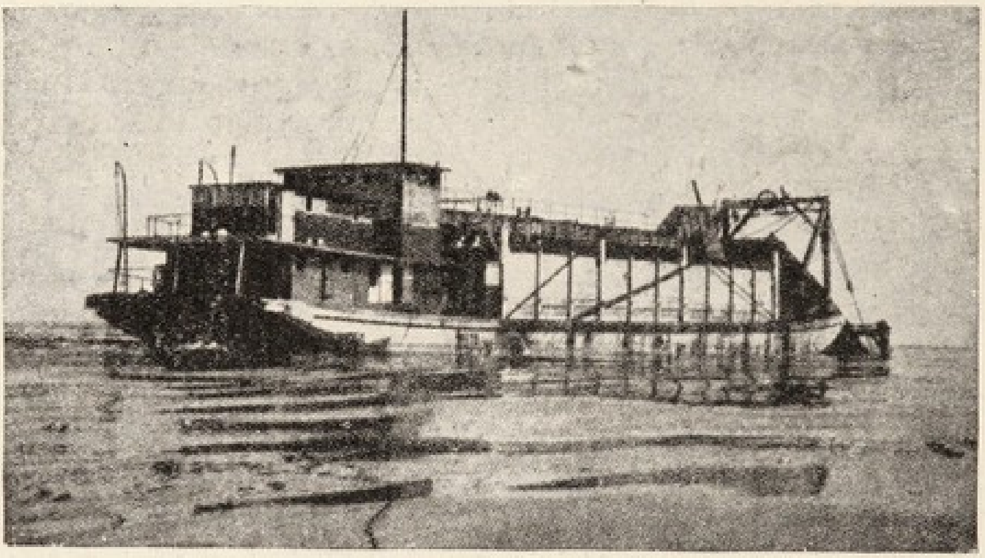


FIG. 57. — Machine for collecting seaweed, with elevator-loading apparatus (on the right).

(Repr. from *U. S. Dep. of Agr., Yearbook*, 1916).

collect from 12.5 to 60 tons of seaweed per hour. In favourable weather they go as far as 2 or 3 miles from the shore travelling at a speed of 4 miles an hour and collecting in 1 hour over 25 *short tons* of seaweed. This was sold, in 1915, at 20 *cents* per *short ton* (907 kg.) of moist seawed delivered at the factory. The cutting of the seaweed is done, on the average, 3 times a year.

(1) Before the war (1913-1914) the United States imported the following quantities of potassic salts of German origin : 1,060,000 *long tons* (1016 kg.) including 230,000 *long tons* of chloride 80 % pure, 45,000 *long tons* of sulphate 90 % pure, 261,000 *long tons* of crude salts with 20 % of potash and 526,000 *long tons* of kainite with 12.4 % of potash. These quantities correspond to 413,000 tons of pure chloride of potassium.

The American production of potash, during the last 6 years, rose from 1090 metric tons in 1915 to 54,803 tons in 1918, then fell to 30,899 tons in 1919 to increase again to 48,625 tons in 1920. Of the total amounting to 177,000 tons produced in the 6 years 1915-1920, 10 % were obtained from beds of potassic minerals, 70 % from deposits of soluble salts and 20 % from organic materials. The value of the above-mentioned total quantity amounts to 58 million dollars (Cf. *U. S. Department of Agriculture, Yearbook*, 1920, p. 375).

The extent and importance of the *kelp* formations of the North American Pacific coasts were estimated as follows in 1915 : — Area 1010 sq. km. — fresh seaweed 60,254,388 metric tons — corresponding chloride of potassium 2,302,256 metric tons. On the supposition that all the potassic chloride could be extracted, it would represent

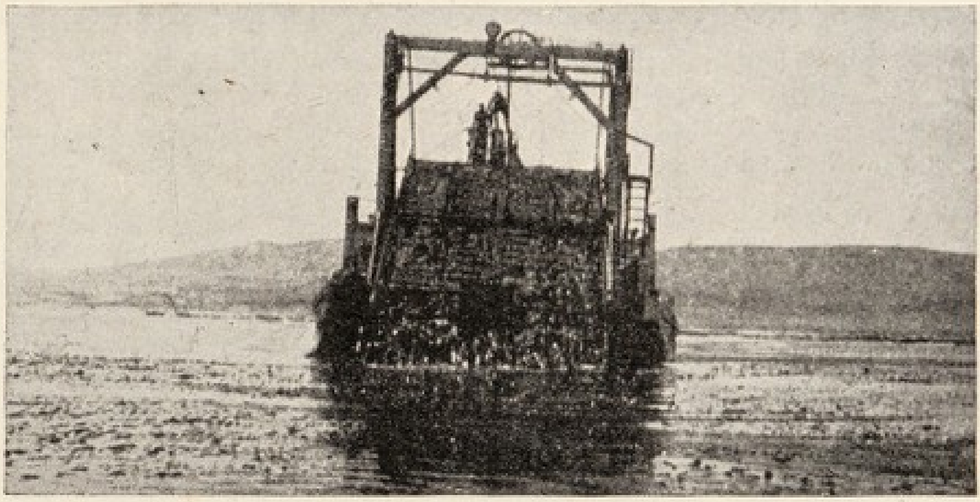


Fig. 58. — The machine of fig. 2, seen from behind.
(Repr. from, *U. S. Dep. of Agr., Yearbook*, 1916).

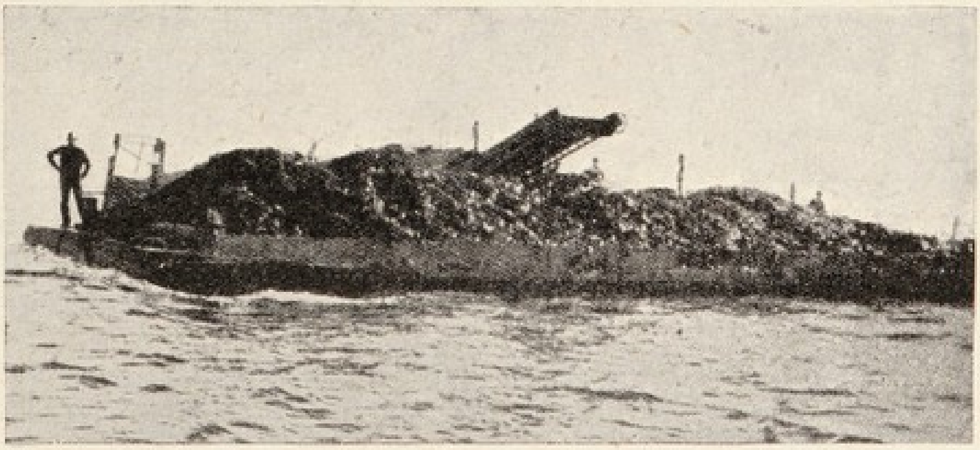


Fig. 59. — Lighter for the transport of the collected seaweed.
(Repr. from *U. S. Dep. of Agr., Yearbook*, 1916).

a value of nearly 82 million *dollars*. From Puget Sound in Alaska the annual production of wet seaweed has risen to an average of 11,930,000 tons.

To get 1 ton of ash, it requires 21 to 22 tons of moist seaweed with 4 % of potash. Air dried, the seaweed contains 15 % of potash (K_2O), 2 % of nitrogen and 1.5 % of phosphoric anhydride. It is easily pulverised. Drying can be done in revolving ovens and the dry product contains as much as 25 % of potassic chloride.

In the United States they have tried to improve the system of incineration by recovering the by-products. With this object the "Bureau of Fertilizers" has established at Summerland (California) an Experimental Station for the utilisation of seaweed (fig. 60), with a credit of 175,000 *dollars*, which will study specially the extraction of potash from seaweeds : as soon as the latter are collected they are dried in revolving ovens, then subjected to dry distillation in retorts similar to those in which metallurgic coke is made (see fig. 66). In this way ammonia, burning gas, tar, etc., were obtained ; the residue from the retorts is subjected to lixiviation, which dissolves the potash salts and leaves the charcoal, used as fuel.

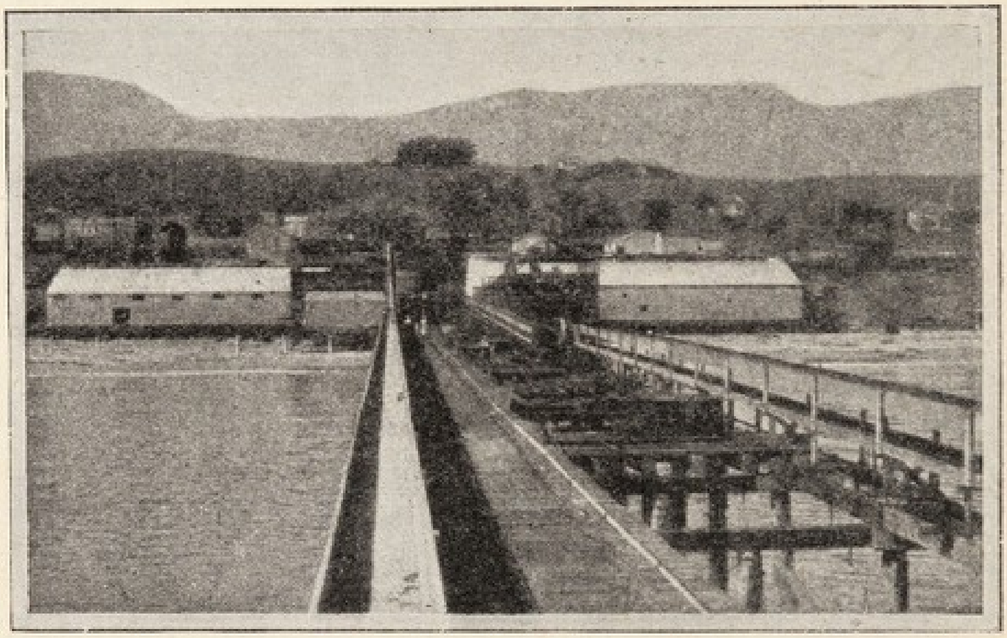


FIG. 60. — General view of the Summerland Station (Cal.)
(Repr. from *U. S. Dep. of Agr., Yearbook,* 1920).

This Station treated, in 1920, 100 tons of fresh seaweed per day and obtained 2 tons of 80 % potassic salts, 1500 lbs. of charcoal and other by-products.

Application was made to the States concerned (California, Oregon, Washington and the territory of Alaska) and to the Federal Congress for legislation, which would prevent irregular and unsystematic collection of seaweed and would guarantee to the capital invested in this industry some certainty of a regular supply of raw material. In 1915 in the United States the development of the production of potash from *kelp* was hardly yet taken into account, and in 1916 the expediency of utilising seaweed at places at a distance from the coasts where it is collected was called in question (1) ; on the other hand the Secretary of Agriculture stated, on one of his Re-

(1) Cf. *U. S. Dep. of Agric., Yearbook,* 1916, p. 309.

ports, that the most abundant and immediately utilisable source of potash was to be found in the gigantic algae of thePacific coasts.

After Germany had prohibited, in 1915, the export of her potassic salts, eight large establishments were founded in California for the extraction of potash from seaweed ; their cost varied between 50,000 *dollars* and 2 million *dollars*. Some of the machines for collecting the seaweed had a capacity of 2500 tons. By September 1916, 125,000 tons of seaweed had been collected yielding about 10 % of dry product, from which the establishments at work were only extracting potassic salts, whereas they ought also to have been producing other by-products; little attention was however paid to these because of the high

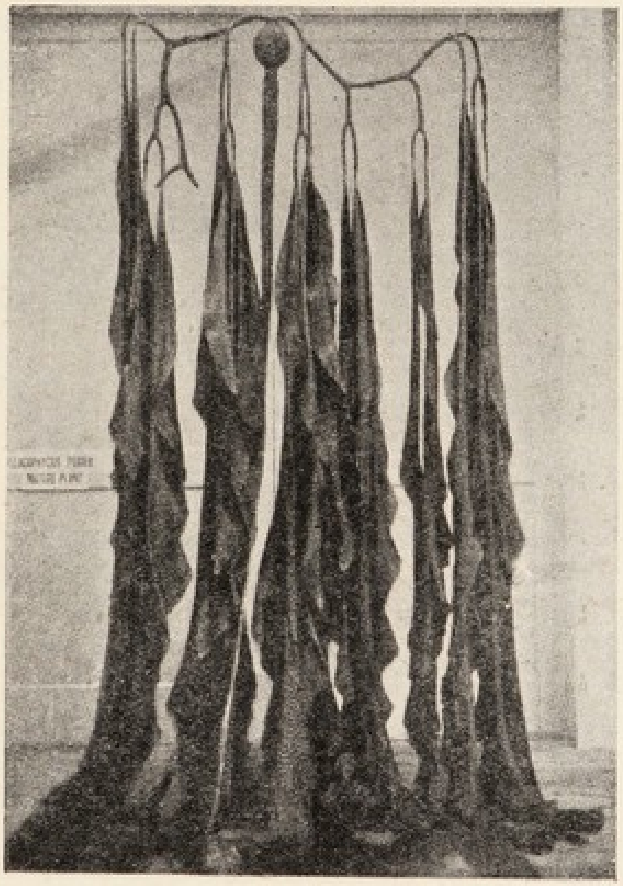


FIG. 61. — *Pelagophycus porra.*

From BURD in Coll. of Agr. — Agr. Exp. Stat. Berkeley, Cal., *Bull.*, No. 248, 1915.

FIG. 62. — *Alaria oblonga.*

From FR. OLTMANNS, Morphologie u. Biol. der Algen. Jena, G. Fischer, 1922, Vol. II.

price reached by potash. Manufacture on such lines would prob ably have become impossible on the restoration of normal market conditions (1).

Pacific *kelp*, from Mexico up to Behring's Sea, includes the following species :— *Pelagophycus porra* (Fig. 61) — *Alaria oblonga*, *A. fistulosa* (" stringy kelp ") (Fig. 62) — *Nereocystis Luetkeana* (" bull kelp "

(1) In 1917 and 1918 there were on the Pacific coast ten companies for making potash from seaweed. The average content of the alga was 16 % of K_2O in the dry material, 30 % in the ash, and 50 % in the refined salts. According to the figures supplied by the Geological Survey the total product ón was 4300 tons per annum.

or "bladder kelp") (Fig. 63) — *Macrocystis pyrifera* ("California kelp"). (Fig. 64). The last two are the most important commercially. There are besides: — *Egregia* (Fig. 65) and *Iridacea* spp., *Laminaria Andersonii*, etc.

The leafy expansions of the *Macrocystis* are about 14 inches long; the stalks are, on the average, 100 feet long, but some of them are found attaining a length of 1000 feet.

Alaria sp. has very short stalks, but the leafy expanisons are, on the average,

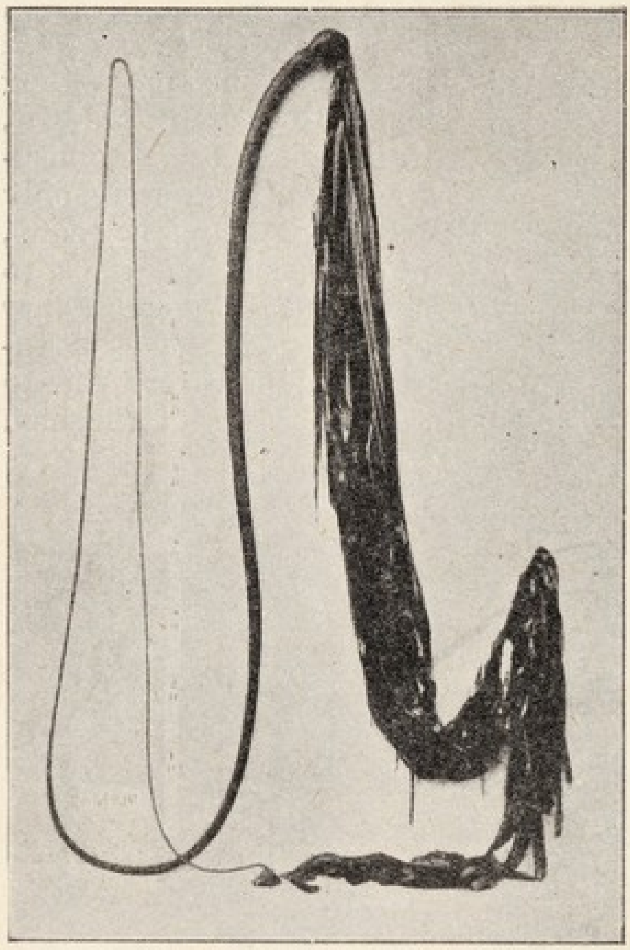


FIG. 63. — *Nereocystis Luetkeana*.
From BURD, op. cit.

FIG. 64. — *Macrocystis pyrifera*.
From FR. OLTMANNS, op. cit., Vol. II.

40 feet long. These two seaweeds are perennial, while *Nereocystis* sp. is annual. The following are the results of analysis of the dry matter :—

	Organic matter	Potash	Nitrogen	Iodine
Nereocystis	47.75 %	21.49 %	1.80 %	0.11 %
Macrocystis	63.00	13.63	1.83	0.19

The quantity of dry seaweed corresponding with fresh seaweed varies with the species :— from 100 tons of fresh *Macrocystis*, about 13.2 tons of dry seaweed containing 2.53 tons of potash are obtained; the same weight of *Nereocystis* yields 8.6 tons of dry seaweed containing 1.6 ton of potash; lastly for *Alaria* sp., we get respectively 13.7 tons and 1.33 ton. Considering only the first two of these seaweeds, it may be allowed that, on the average, 100 tons of fresh seaweed yields 10.9 tons of dry seaweed containing 18.9 % of potash, 2 % of nitrogen and 1.5 % of phosphoric acid.

Composition of the ash of the part collected of the following species.

	Macrocystis pyrifera	*Nereocystis Luetkeana*	*Pelagophycus porra*
Calcium	4.96 %	2.10 %	2.09 %
Magnesium	2.24	1.55	1.71
Sodium	10.52	11.05	8.63
Potassium	29.46	32.66	34.73
Ferric oxide / Alumina	0.43	0.17	0.26
Chlorine	34.93	40.89	40.83
Sulphuric acid	7.92	4.63	4.84
Carbonic acid	4.44	3.10	1.66
Phosphoric acid	2.30	1.91	2.18
	97.20 %	98.06 %	96.93 %
Total ash in the dry matter	35.62	50.57	52.66

The following are the methods of extraction employed:

(*a*) Partial drying, separation of the saline efflorescences (containing probably less than ⅓ of total potash), then complete drying and trituration of the residue, to be used as low grade potassic and nitrogenous fertiliser.

It is well to put them on the soil mixed with lime, or better, with basic slag or superphosphate.

This method does not appear to be suitable for the *Macrocystis*.

(*b*) Extraction of the greater part of the potash and iodine from the fresh material by lixiviation, complete evaporation of the solution and calcination of the residue of the lixiviated seaweed, in which there remains ²/₃ or more of organic matter yielding a humiferous material containing about 3 % of nitrogen. This method, which entails small losses of the constituents, requires much labour over the evaporation of the solution containing viscous matter.

According to the English patent Nº 1766

FIG. 65. — *Egregia Merziesii*. 1. The growing plant. 2. Lower part. 3. Upper part. 4. Whole plant.

From FR. OLTMANNS, op. cit., Vol. II.

of 1915, taken out by Messrs. Beborg, Testrup and Techno-Chemical Laboratory, the seaweed is reduced to pulp and driven under pressure into an oven, afterwards cooled again and pressed to separate the moisture which retains all the potash, soda and iodine. As soon as the salts have been separated from the organic matter it is easy to purify them by successive crystallizations and the iodine is extracted from the mother liquid. This process yields pure chlorides of potassium and of sodium, iodide of potassium, and the residue of the seaweed furnishes a food for livestock containing 4.5 % of nitrogen.

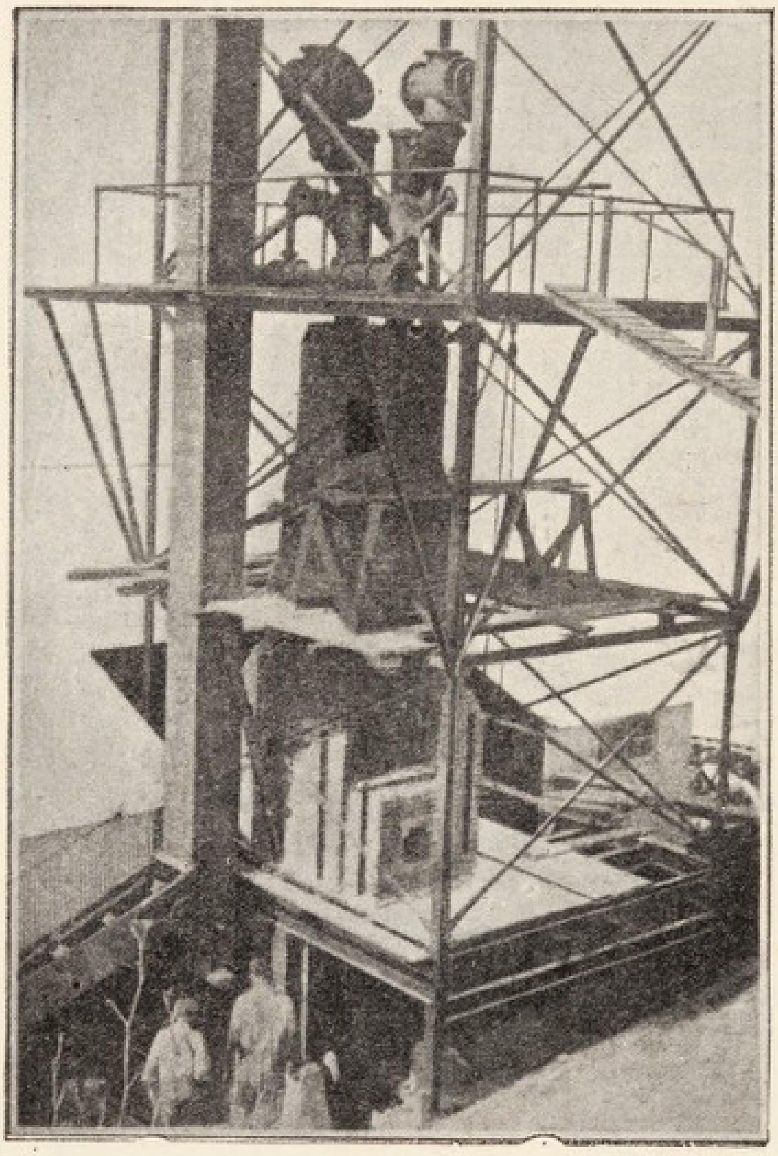


FIG. 66. — Retort for the combustion of seaweed for the extraction of potash.

(Reprod. from the *Scientific American*, Feb., 1922).

(*c*) Calcination of the dry seaweeds, lixiviation of the ash, separation of the greater part of the potash and of about 80 % of the iodine. This method gives rise to losses of nitrogen and combustible matter, but it is simple and economical.

The solution of the lixiviation of the ash, when from 24° to 26.4°. Bé is shown, is allowed to clear, then it is placed in a large iron hemispherical boiler. The liquid is heated by steam and stirred and continues to concentrate up to 33.3° to 35.4° Bé. Then the liquid while still hot is poured into the crystallising pans. The solid residue thus obtained contains about 60 % of potassium sulphate and the remainder is sodium sulphate and sodium chloride. From the mother liquor of this crystallisation chloride of potassium is obtained to about 90 % of purity. From the residual mother liquor iodine is obtained.

The residue of the lixiviation of the ash of seaweed is used in France as a fertiliser: it contains in a considerable proportion carbonate and phosphate of lime and magnesium. According to A. A. MOFFAT this residuum has the following average composition: carbonate of calcium 20.50 — sulphate of calcium 3.06 — sulphide of calcium 1.70 — carbonate of magnesium 9.11 — salts of potash and soda 1.50 — mineral phosphates 6.72 — carbon 3.09 — flint and sand 20.82 — moisture 33.50.

The cost of preparation in the United States, in 1915, was as follows per *short ton* of 907 kg. :—

Cutting, collection and transport of the seaweed	*dollars*	1.83
Drying	"	1.64
Trituration and manipulation	"	1.00
General expenses, interest, etc.	"	1.00
Total . . .	*dollars*	5.47

The profit was at that time 10 *dollars* (1).

(1) It was profitable to extract potash from seaweeds during the war on account of the scarcity of potash, but in normal conditions with ordinary methods it is too costly. At present the Bureau of Soils is testing a method for extracting potash from seaweed in normal times.

In the combustion of dried seaweed, ammonia, oils, creosote and pitch are lost, and charcoal (kelpchar) an energetic decoloriser, and ash with potassic salts and iodine are obtained. The results hitherto obtained show that the charcoal and the iodine suffice to enable potash to be obtained at a commercial price capable of competing with that of potash from other sources (Cf. *Scientific American*, Feb. 1922, p. 107).

For a detailed account of the manufacture of "Kelpchar", Cf. J. W. TURRENTINE and H. G. TANNER, Potash from Kelp. The Applicability of Kelpchar as a Bleaching and Purifying Agent. *The Journ. of Ind. and Engin., Chem.* Vol. 14, No. 1, Washington, 1922, p. 19. — In the same magazine (1918, No. 10, p. 812). ZERBEIN has shown that a good decolorising charcoal can be made with Pacific coast Kelp (*Macrocystis pyrifera*), which is the seaweed on which the Kelp products industry of South California is based.

The quantities of potash extracted from seaweed in the United States during the war were as follows :—

Years	1916	1917	1918
Metric tons.	1412	3240	4358

(Cf. INTERN. INST. OF AGRIC. International Trade in Fertilisers, year 5, No. 3, 1921).

Active carbon can be made from various vegetable residues, as well as from seaweed, especially from sawdust of different woods, sugar maple, coco nut shells, etc.

The impregnation of the sawdust with chloride of magnesium or its admixture with phosphate of calcium in equal quantities gives the best results for decoloration of syrup.

For the formation of active carbon by distillation of a carbonaceous substance it is essential that the combustion temperature should be rather low so that the carbon may absorb a certain quantity of hydrocarbons (*).

It is advisable to distill *rice husk*, instead of burning it in open pans, to obtain carbon gas and distillation products. There need be no interference with the process from excess of fibre for the bulk would be lessened by the reduction of the CO_2 to CO in the zone of combustion.

The husk on distillation yields from 38 to 40 % of coke, removing from it the 13 % of ash remaining there is still a yield of pure carbon at least equal to that of wood.

For distillation to produce vegetable carbon it is useful to mix the husk with dry sawdust so as to reduce the percentage of ash (30 %) in the carbon so formed (**).

(*) E. G. ARDAGH, Les Carbons activés. *La Rev. des Prod. Chim.*, No. 6. Paris, 1922.

(**) Cf. A. BOSCO, Distillazione secca dei cascami dei vegetali. *Giorn. di Chim. Ind. e Appl.*, year IV, No. 4. Milan, 1922.

(*d*) Steeping in large pans, with the temperature accurately controlled and aeration with compressed air for 10 to 14 days. The decomposition of the cellulose and of the mucilaginous substances form acids of the acetic acid series, while the mineral salts go into solution. Then lime is added and salts are formed corresponding to the acetic, butyric and propionic acids.

When fermentation has proceeded far enough, it is arrested by raising the temperature up to 100° C: the insoluble matter is separated from the liquid which is allowed to clear. This is then treated in an evaporating apparatus at low pressure (quadruple effect) till a crystalline deposit is produced known as *taffy* which is separated. By a subsequent process calcium acetate is obtained and then potassium chloride. From *taffy* there are manufactured on a large scale: ethyl butyrate, ethyl propionate, methyl-ethyl-ketone and other ketones used as solvents.

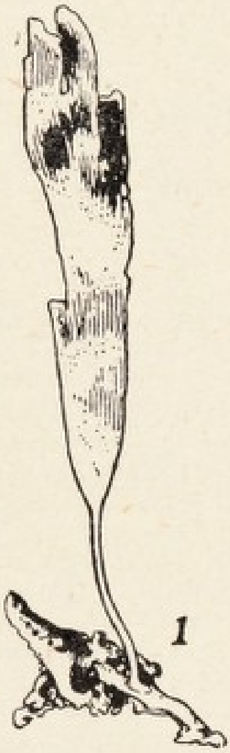


Fig. 67. — *Laminaria* (*digitata* ?)

From Fr. Oltmanns, op. cit., Vol. II.

From the insoluble mass left from the steeping, algine can be extracted with carbonate of soda.

According to R. K. Meade (1) light has not been thrown on the possibility of commercial production of potassic salts from seaweed, as for production of 20 tons of potash it is necessary to handle about 1500 tons of raw material containing 1350 tons of water, and rotatory drying machinery to evaporate this quantity would require 38,000 gallons of mineral oil.

On the coasts of Scotland *Laminaria digitata* (fig. 67) and *L. stenophylla*, rich in potash and iodine, are chiefly used. They are dried, and then burnt till the ash begins to melt there being no appreciable loss of potash and iodine, provided that no silica and limestone are present.

In Ireland and in Japan (2) the seaweeds are even cultivated, that is to say beds of siliceous stones, or bundles of bamboo are placed for them in the tidal zone. The most valuable species for that zone is *Fucus vesiculosus*; in deep water the principal species belong to the genus *Laminaria*; these are almost always used in the natural state as manure for potatoes.

In France and Norway also enormous quantities of seaweed are used for the extraction of potash and iodine. The following coastal species (Zosterae, red seaweeds, Fucaceae) are so used and at times

(1) R. K. Meade, The Possibilities of Developing an American Potash Industry, *Metall. and Chem. Eng.*, 1917.

(2) In Japan the alga called *amanori* is cultivated over more than 2,200 acres with a production of more than 2100 metric tons of algae. These grow very quickly on bundles of bamboo stalks and are gathered from January to March. They are dried in packets and make various dishes.

others (Laminariaceae, Fucaceae, Zosterae). The deep water *Fucus* are most suitable for the extraction of potash. In France, Norway and in the United Kingdom 350,000 metric tons were collected in 1916, and 175 tons of iodine, 7000 tons of potassic salts and 15,000 tons of lixiviated residues were obtained from this quantity. According to GLOESS, by employing more rational methods of extraction, these figures might be considerably increased. In a fresh state, these *Fucus* contain 4 % of potash (a proportion corresponding to 25 % in dry *Fucus*) which can be extracted by efflorescence and lixiviation, which enables a crude salt containing 63 % of potassic chloride, corresponding to 41 % of potash, to be obtained. By eliminating only the iodides and bromides, by lixiviation with pure water or with acidulated water, a humo-potassic nitrogenous fertiliser is obtained as residue. Japan also produces large quantities of iodine and potassic salts derived from seaweed.

The kinds of algae chiefly used in Japan for extraction of iodine and of potash salts, especially chlorates, are : *Laminaria* sp., *Ecklonia cava*, *E. bicyclis* and *Sargassum* spp.

Seaweed has been used directly as fertiliser from early times along the coasts of Great Britain, and serve to add to the soil potash, nitrogen and organic matter of a kind that easily decomposes. The following percentages of the fertilising elements present in some kinds of seaweed common round the shores of the British Isles refer to dry matter :

	Potash	Nitrogen	Phosphoric acid
	—	—	—
Fucus sp.	5.88	2.25	0.66
F. ceranoides	3.80	1.25	0.03
F. nodosus	4.73	2.60	0.32
Laminaria sp.	6.84	2.57	0.80
Fucus serratus	3.70	2.33	0.05

On the coastal lands of Scotland they are spread on light soils in doses of 25 to 30 long tons or so per acre. In Devon and Cornwall for manuring potatoes or fleshy roots seaweed is used which has been made to ferment by mixing with sand.

According to certain experiments in manuring made in France (1). by using *Fucus* directly for manuring potatoes it appeared that 12,800 kg. of *Fucus* have the same value as fertiliser as 3500 kg. of stable manure, in respect of potash and nitrogen. It was also proved that 6000 kg. of this seaweed are equal to 200 kg. of mineral nitrogen and to 200 kg. of chloride of potassium. By supplementing organic fertiliser with superphosphate a high production is obtained.

This seems the right place to give some brief information about two species belonging to the Naiadaceae, commonly but incorrectly called seaweed : *Posidonia oceanica* (see fig. 27) and *P. australis*.

(1) VINCENT, L'Emploi des Goëmons dans la culture des pommes de terre, in *La Vie Agricole et Rurale*, Vol. XXI, No. 44, Paris, 1922.

The first species abounds on some of the Italian beaches, especially in Sicily and is plentiful in Tripolitania, Cyrenaica, Tunisia, etc. It is used here and there directly as manure by letting it ferment either by itself in heaps, or else with farmyard manure. It also serves as litter or as packing material. In a green state, it is sometimes used as food for livestock and, during the war, that use was recommended (see p.) : in fact attempts were made to utilise the large banks which occur in Tripolitania, where, according to TROTTER, " this species forms at certain places (as at Busceifa for example) such enormous deposits as to constitute a new resource for the region if improved methods of utilisation were adopted ". A move was made in this direction by a group formed at Rome immediately after the war with the object of obtaining from the Ministry of the Colonies the right of exploiting the large banks of *Posidonia oceanica* in Tripolitania.

I was charged by this group to investigate whether it was possible to make use of this plant, especially in view of iodine extraction and production of fibre for paper-making.

The extraction of iodine was worth careful study, all the more so as the experimentalists who previously dealt with this plant had not taken count of the question of iodine, which is extracted from seaweed in Scotland, Ireland, France, Norway and Japan.

Having analysed a sample of *Posidonia* which had been sent to me from Tripoli, I obtained the following results, for air dried material

Crude ash	23.80 %
Iodine in the ash (CARNOT's method)	0.0181 %

that is to say that :

1 ton of ash contains.	181	gm. of iodine
100 parts of air dried seaweed contain .	0.00026	» of iodine

Evidently the quantity of iodine which could be extracted was so small that there was no reason to proceed further in the matter. It should also be remarked that this plant proved difficult to burn and that various laboratory contrivances had to be brought into action before it could be completely incinerated (1).

As to the use of this plant for obtaining fibre (fig. 68) for paper making, I was unable to make the necessary research, but its very poor combustibility rather goes to prove the contrary ; however in this connection it is well to recall the results of researches made by I. READ and H. G. SMITH with *Posidonia australis*, a species very closely allied to *P. oceanica*. These two experts studied this plant particularly as regards the fibre, present in the leaves and the stalks.

The plant is abundant on the coast of Western and South Australia, New South Wales, Tasmania and probably all round the Australian Continent. It is calculated that the deposits in the south could

(1) See also : LOSANA, L. and CROCE, P. E. Utilizzazione di ceneri di piante marine della Libia, in *Ann. di Chim. appl.*, Year VII, No. 1, Rome, 1923.

furnish 5,325,000 metric tons of fibre, which is purified by washing with nitric acid at 2 % strength for several hours. But the fibre is short, coarse, irregular in length, wanting in flexibility and strength, so that it is only fit for coarse textiles, mixed with wool and other fibres. It dyes well and is a bad conductor of heat, is resistant to chemical and bacterial agents. It might serve for making paper if a process of separating the elementary fibres should be invented, for these fibres closely resemble those of esparto. The filaments, which are 10 to 17

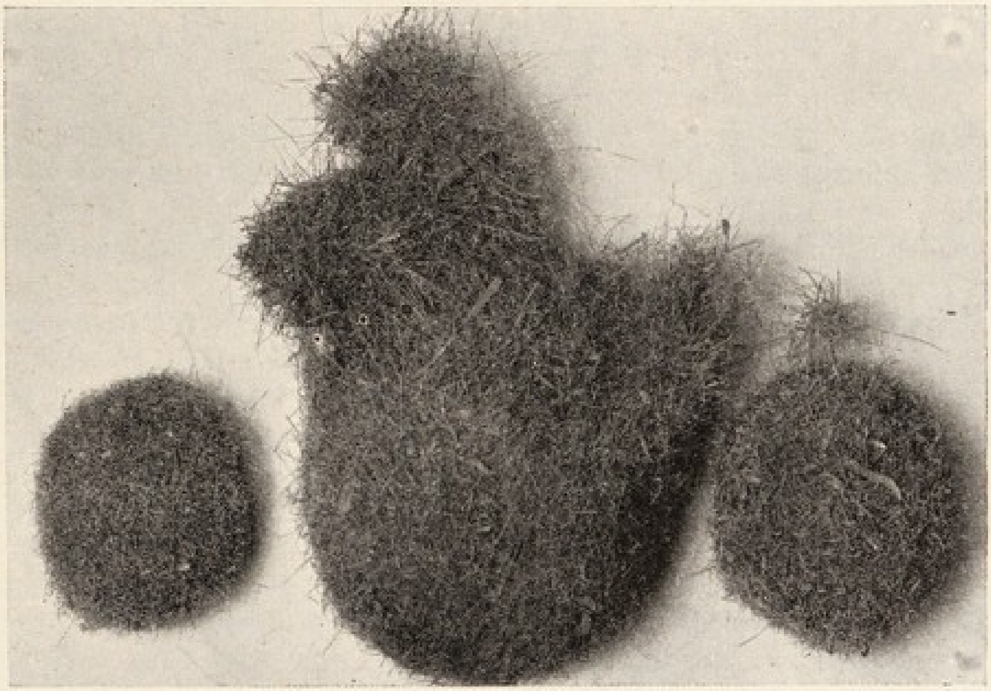


Fig. 68. — Masses of *Posidonia oceanica* fibre, felted and trown up by the action of the waves.

(Coast of *Maccarese*, Rome).

cm. long, are very fragile. The elementary fibres are only from 0.5 to 1 mm. long.

From a chemical standpoint, this fibre may be considered as a lignocellulose strongly resistant to cellulose solvents. The crude fibre treated with chlorine furnishes 55 % of cellulose.

When seaweed ash is treated for the extraction of iodine, fertilising products are also obtained.

As that industry cannot be dealt with here, only the products obtained and their chief uses will be indicated :

Products obtained	Uses
1) Insoluble matter in the ash.	Bottle glass
2) Sulphate of potash.	Fertiliser
3) Chloride and carbonate of sodium. . .	Soda industry
4) Chloride of potassium	Fertiliser
5) Sulphur.	Various
6) Iodine	Medicine, Chemistry
7) Sulphate of manganese (1)	Fertiliser.

2. — Straw.

Generally this is refuse containing little fertilising matter. The straw of leguminous plants contains more nitrogen than that of other plants.

Several kinds of straw are used as food for livestock, but this is not the place to discuss such use.

Straw will be considered here first as used for litter or fermented by itself or with dung and carried later to the land. But that use is so well known that there is no need to say more about it. A patent process may however be mentioned for the treatment of straw and other vegetable matter with the object of employing them as fertilisers : this will be described in the next chapter. Here it may simply be noted that dung is of great value to the soil and that straw is of great importance in promoting its action as in decomposing it sets up favourable conditions in the soil for the multiplication and functioning of valuable micro-organisms. It would however be very useful to return all straw not used for feed back to the soil to supply it with the essential organic material.

In the chapter treating of straw as food for livestock statistical data were given regarding the world's production of the straws of the principal cereals, and the total quantities of nutritive elements contained in them were calculated. Now, using the same figures of total production, the fertilising value of the straw is reduced to that of farm-yard manure and calculated by taking as basis the fertilising element occurring in smallest quantity, namely phosphoric anhydride. We know that the composition of farmyard manure is very variable (2); we may allow as average composition : nitrogen 4 to 5 per 1000 — phosphoric anhydride 2 to 3 per 1000 — potash 5 per 1000. These fertilising elements are derived from the litter and from the excreta and occur in a more assimilable condition in the excreta ; as however it is here merely a question of the straw, that is to say of the litter alone, its fertilising value as farmyard manure may be indicated

(1) This is obtained by treating the iodic solution with sulphuric acid and dioxide of manganese. On the other hand it is not formed when the chlorine process or the phosphoric acid process is applied.

(2) Cf. Bruttini, A., I Concimi, Casalmonferrato, 1912, p. 114.

by selecting a lower average content of phosphoric acid than that mentioned above; for this reason the basis taken is the proportion of 1,5 per 1000 of phosphoric acid and for the average composition of straw the data from WOLFF'S tables are taken.

Quantity of fertilising elements contained in straw and the corresponding farmyard manure.

Crops	Total straw for N and S Hemispheres — Averages of 1904-1919	Phosphoric acid	Total Nitrogen	Potash	Farmyard manure corresponding to the Phosphoric acid
	metric tons	metric tons	metric tons	metric tons	metric tons
Wheat	216,967,702	477,329 (0.22 %)	1,041 446 (0.48 %)	1,366,896 (0.63 %)	3,182,193
Rye	75,151,614	187,879 (0.25 %)	300,606 (0.40 %)	646,304 (0.86 %)	1,252,596
Barley	63,333,784	120,334 (0.19 %)	405,336 (0.64 %)	677,672 (1.07 %)	802,228
Oats	112,622,080	315,342 (0.28 %)	630,683 (0.56 %)	1,835,740 (1.63 %)	2,102,279
Maize	188,887,476	717,772 (0.38 %)	906,660 (0.48 %)	3,097,754 (1.64 %)	4,785,149
Rice	110,049,895	286,130 (0.26 %)	924,419 (0.84 %)	176,080 (0.16 %)	1,907,531
Totals . . .	**767,012,551**	**2,104,786**	**4,209,150**	**7,800,446**	**14,031,976**

The farmyard manure which can be obtained with the amount of straw indicated above would be much increased by using the straw merely as litter, but we must consider directly the total figure found by the statistics, which, needless to say, is correct as regards value but imaginary in its application.

Let us take this straw as reduced, alone or in composts, by fermentation until its weight per cubic m. is 400 kg., that is to say, the same as that of fresh stable manure with plenty of straw. We may assume that for an average

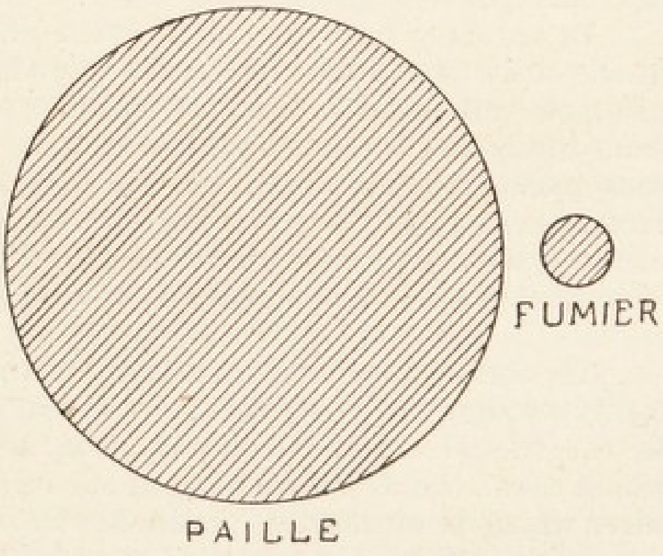


FIG. 69. — Graphic representation of "cereal straw" produced annually in the world and of the corresponding "straw-manure". Paille = Straw — Fumier = Manure.

manuring 30 m. tons of such manure per hectare are necessary (giving 45 kg. of nitrogen) and we are then able to state the number of hectares which could be manured if all the straw of the cereals produced in the world was used, after maceration, as manure.

$$\frac{14{,}031.976 \text{ m. tons}}{30 \quad \text{m. tons}} = 467{,}732 \text{ hectares } (1{,}155{,}749 \text{ acres}).$$

3. — Straw directly converted into fertiliser (1).

Artificial farmyard manure. — The considerable extension of cereal cultivation in the belligerent countries during the war resulted in large supplies of straw in excess of the usual requisements. This fact suggested to Messrs. H. B. HUTCHINSON and E. H. RICHARDS the idea of trying to convert it into farm manure, in view also of the short supplies of this for ordinary manuring. Experiments were made on this subject at the Experimental Station of Rothamsted, with funds provided by the Food Production Department, from which it was possible to deduce a patented method (British patent No. 152387).

As a matter of fact, we do not consider as very appropriate the name "Artificial Farmyard Manure" given to straw treated by that method, for hitherto it has always been understood by farmyard manure the complex manure resulting from the mixture, more or less fermented, of the litter of animals with their solid and liquid excreta. We think that the name "straw-manure" would be more appropriate,

Although the so-called "artificial farmyard manure" closely resembles stable manure in its physical properties, it nevertheless differs from it considerably in its chemical properties, for stable manure contains, besides nitrogen, appreciable quantities of phosphoric acid and potash derived from foods.

In ordinary farmyard manure the nitrogen causing decomposition of the straw is supplied exclusively by the urine since the faeces fix nitrogen more readily than they part with it. Moreover, any nitrogen from the faeces is readily subject to loss not preventible by the numerous means recommended for the purpose; the means suggested by RUSSELL and HUTCHINSON consists in greatly increasing the amount of litter, so that it can absorb and retain the ammoniacal products generated by the decomposition of this nitrogen.

To obtain good decomposition of the straw to be converted into farmyard manure it requires : — 1) the presence of the air necessary to the life of aerobic bacteria, such as *Spirochaeta cytophaga*, etc., which cause the decomposition of the cellulose ; 2) a suitable temperature, which is ordinarily produced by the effect of fermentation ;

(1) Cf.: 1) H. B. HUTCHINSON and E. H. RICHARDS, Artificial Farm Manure, in *The Journal of the Ministry of Agriculture*, Vol. XXVIII, No. 5, London, 1921. — 2) E. H. RICHARDS and M. G. WECKES, The Institute of Civil Engineers, in *Engineering Conference* 1921, Sect. II, "Straw Filters for Sewage Purification", London, 1921.

3) the presence of soluble nitrogenous compounds in suitable quantity, either absolutely or in proportion to the mass.

The decomposition of the straw is more active in presence of directly or indirectly assimilable nitrogenous compounds and in presence of a neutral or slightly alkaline reaction. As useful nitrogenous compounds may be mentioned : urine, urea, carbonate of ammonia, peptones, etc.

The maximum concentration of the solution of these nitrogenous compounds should be sensibly less than that of the weakest undiluted urine, so that a thoroughly decomposed farmyard manure cannot be obtained by using urine alone, without entailing considerable losses.

In the decomposition of straw three phases occur : 1. the straw, super-saturated with nitrogen, loses nitrogen ; 2. the straw, containing the right quantity of nitrogen, decomposes without appreciable loss of that element ; 3. the straw, which contains a small quantity of nitrogen, fixes it, owing mainly to bacterial activity, until it reaches the final proportion, 2 % of the dry matter. Generally the nitrogen is fixed in an organic form.

The quantity of nitrogen required for active decomposition of the straw and the quantity of nitrogen which the straw can fix in an ammoniacal state are identical and only vary between 0.70 and 0.75 per 100 of dry straw.

The most suitable substances for supplying the nitrogen required for an active decomposition of the straw to be converted into " artificial farmyard manure " are urea and carbonate of ammonia, but they are too expensive, and they are profitably replaced by cyanamide of calcium or sulphate of ammonia. The former contains the lime required for neutralizing any acid compound formed during fermentation, while either lime or powdered limestone or lime refuse from soapworks must be added if sulphate of ammonia is used. Generally 37.5 kg of sulphate of ammonia and 50 kg of finely powdered limestone are enough to set up fermentation of 1000 kg. of straw.

The main obstacle to this conversion is the slowness with which the straw absorbs the necessary moisture. When receptacles are available, the straw can be left in them for 2 to 4 days, but when the straw has to be treated in heaps on the ground, it is no use throwing large quantities of water on it ; it is better to sprinkle it moderately every 48 hours, as far as required so that the straw becomes moist to the middle of the heaps. The substance intended to supply nitrogen for the active fermentation is then applied, either by means of a solution if the substance is soluble or by superficial powdering if it is insoluble (cyanamide), followed by watering to ensure its penetrating into the interior of the heap.

Straw filters for sewage purification. — This process forms part of that which has just been described and in a manner depends on it.

On the average $^3/_5$ of the nitrogen in sewage is formed of ammonia compounds derived from urine. Owing to the great dilution of the ammonia no method had been suggested for recovering this nitrogen.

In well managed purification installations, much of the ammonia is nitrified, but gets lost in the sea, while part of the nitrogen returns in the air in the elementary state.

The quoted above writers have shown, by experiments made at Rothamsted, that very dilute ammonia in sewage can be utilised as fertiliser by means of a straw filter.

In the laboratory experiments, it was seen that by causing a solution of carbonate of ammonia of equal density to that of sewage (namely 1 part of nitrogen per 10,000 parts of water) to pass through straw, to the extent of 250 gallons per cubic yard of straw per day, 5 % of the nitrogen which passed through the filter was retained the first day, and that this amount increased up to the 20th day, when the effluent water contained only 1 % of nitrogen so that 99 % of it remained on the filter. At that moment the filter was saturated with nitrogen. Another filter of wheat straw retained up to 86 % of the nitrogen contained in the ammoniacal solution.

When sewage was filtered, the filter retained 72 % of its nitrogen.

When the straw used as filter is removed and heaped up, it continues to ferment, much improving its physical nature as substitute for farmyard manure.

As regards the fixation of nitrogen in the straw filters by the constant passage of the sewage water, the filters gave the best results after 20 days passage. The utility of making a filter with sections, in which the straw from one section was constantly passed on to the next, so that the sewage water always encountered fresh straw in commencing its passage and that of the most active section when ending it, was recognised. It was also recognised that 3 sections sufficed, and to avoid moving the straw with forks from one section to the next a special arrangement of the bottoms of the receptacles was adopted.

With a receptacle of 960 gallon capacity, 65 % of the nitrogen was recovered from the sewage water.

The following are some results of analyses :

	Sewage water	Effluent water
Ammoniacal nitrogen in 100,000 parts	18.92 %	10.19 %
Nitrogen in the natural straw.	0.50	—
" " " straw removed from the filter. .	1.62	—
" " this straw after 6 monts	2.06	—

For fixing the whole of the nitrogen in the sewage of an inhabited centre, 2 lbs of straw per day per inhabitant are required.

The straw can be replaced by sawdust and other vegetable refuse.

4. — Sawdust and Wood shavings (1).

This refuse is too poor in nitrogen to be used directly as fertiliser, but it can be used as litter, owing to its considerable power of absorbtion. The sawdust of wood rich in tannin, as that of oak, chestnut, etc., may be injurious to plants unless it has first undergone thorough fermentation which causes it to lose its acidity.

When the sawdust and shavings cannot be used for industrial uses (as, for example, for the manufacture of nitrocellulose during the war), it is best to use them as fuel or for the production of poor gas, and to use the ash as fertiliser. This ash contains on the average 6.73 % of potash.

5. — Various vegetable offals and residues (2).

Dead leaves. — In the first part of this work mention has been made of the measures taken in Germany during the war to procure enormous quantities of dead leaves. Their utilisation as fertiliser is here briefly described. By dead leaves are meant those which fall from trees, mostly in autumn, and are often used as litter, especially when (as happened during the war and is still the case at present) it is not convenient to use the straw of cereals for that purpose owing to their high cost. When dead leaves are not wanted as litter they can be taken directly to the dung heap to increase its mass, or else they can be incorporated with composts. If the distance to be covered makes their transport difficult, they can be heaped up, burnt and the ashes used, but in this case the nitrogen and organic matter are lost.

Besides the dead leaves which fall from the trees those which fall naturally from numerous herbaceous plants before the harvest, or which after turning yellow fall when harvesting is in progress and are generally left on the ground, may also be considered.

Such is the case of the lower leaves of the tobacco plant, turnips, mangolds, cabbages, wheat, oats, barley, etc.

According to Müntz and Girard the quantity of leaves of certain plants falling, on the average, on a hectare (2.5 acres) are: Wheat 3750 lbs — Oats 3750 lbs. — Rape 2200 lbs. — Poppy 3750 lbs. The withered stalks of potatoes unfit for fodder restore to the soil about 22 lbs. of nitrogen and 4 lbs. of potash per acre. One ton of mangold leaves restores to the soil: nitrogen 8.4 lbs. — phosphoric acid 5.5 lbs. — potash 23.7 lbs. — lime 8.4 lbs. — The fallen leaves of vines restore per acre about 21 lbs. of nitrogen, 4.5 lbs. of phosphoric acid, 7 lbs. of potash and 63 lbs. of lime.

(1) Cf.: 1) P. Razous, op. cit. — 2) Gimingham, C. T., in *The Journal of the Board of Agriculture*, Vol. XXII, No. 2, London, 1915.

(2) Cf. A. Bruttini, op. cit., p. 21 and foll.

	Moisture	Mineral matter	Nitrogen	Phosphoric anhydride	Potash	Lime	Magnesia	Soda	Sulphuric acid	Silicic acid
Silver fir.	132	32.8	—	2.7	2.7	19.5	2.3	0.5	0.8	2.5
Beech	140	46.7	10.0	2.4	2.3	21.2	3.1	0.5	1.0	14.5
Larch	140	34.3	—	1.3	1.6	7.5	2.4	0.5	0.6	19.6
Scotch pine	135	12.2	8 0	1.0	1.3	4.6	1.2	0.5	0.5	1.8
Oak	140	6.1	10.0	2.0	3.5	17.1	4.3	1.3	0.9	15.4

Ferns and other woodland plants. — The chief of these plants is the Bracken fern (*Pteris aquilina*) which contains considerable quantities of nitrogen and potash and is often used as litter, especially in stables in the mountains. It can also be mixed directly with the farmyard manure.

Among other plants of the woods which can be used similarly to the fern are the Heath (*Erica vulgaris*) and the Broom (*Cytisus scoparius*) (Fig. 70).

One ton of dried fern contains about 24.6 kg. of nitrogen and 18.6 kg. of potash.

According to Wolff these three plants contain per 100 parts :—

	Moisture	Organic matter	Nitrogen	Phosphoric acid	Potash	Lime
Ferns	25	70.13	—	0.37	1.86	0.60
Heath	20	—	1.00	0.11	0.21	0.36
Broom.	20	63.40	1.00	0.11	0.50	0.22

According to a paper by E. F. Schutt (1) bracken fern analysed at the Agassiz Agricultural Station (British Columbia) contained : — moisture 6.09 % — ash 7.84 % — nitrogen 1.84 % — phosphoric acid 0.68 % — potash 2.75 % — In the ash, potash may reach 50 %.

Dried ferns rapidly lose their potash : when transport of the ferns themselves is not practicable, the ash will serve as a medium.

Stalks of herbaceous plants. — We include here woody stalks or those containing substances injurious for animals which cannot be used as fodder, as for example, stalks of maize, tobacco, sunflower, Jerusalem artichoke, rape, lupine, sesamum, withered leaves of potatoes, etc.

(1) Cf. Schutt, F. E., in *The Agricultural Gazette of Canada*, Vol. VI, No. 4. Ottawa, 1919.

They are used as litter, or else they are placed to ferment in heaps which are watered frequently with urine or liquid manure.

Prickly Pear Slabs. — The jointings of the prickly pear have been used for a long time in Sicily to manure the land and to keep it cool in summer: they are roughly sliced or bruised with stones and then buried round the trunks of olive or citrus-fruit trees, or in the beds where vegetables are grown. They thus make a special summer green manure, rather than a fertiliser.

Biuso (1) however observes that their use does not suit a soil poor in lime because the acidity of the juice of the slabs makes the plants so manured liable to chlorosis.

In Sicily the residual products of the prickly pear are put on the manure heap or left to make mould on the spot.

Fig. 70. — Broom.

From Francé, op. cit.

Marsh plants. — These are largely used, especially in the Pisa country, under the name of "falasco". It is a mixture of sedges, rushes, galingale, marsh reeds and other paludal species, which are cut when full grown in summer, and used during the year as litter.

Owing to their structure, these plants absorb urine to a smaller extent than the straw of cereals, but have the advantage of bringing into the farm from outside, fertilising matter, and matter which would otherwise only be used as packing material or for making seats of chairs, mats, etc.

According to Prof. F. Sestini, "falasco" contains :— nitrogen 0.893 % — phosphoric anhydride 0.279 % — potash 0.856 % — chloride of sodium 1.344 % — indeterminate matter.

By the method suggested by A. G. Rande of Aachen, weeds are reduced to commercial fertiliser in the following manner :— heaping and fermentation of the plants until they are reduced to pulp, moulding this pulp into briquettes and their rapid drying, finally grinding. The product so obtained contains, according to the kind of plant, from 5 to 9 % of nitrogen (2).

(1) S. Biuso, Il fico d'India in Sicilia, Palermo, 1879, p. 179.

(2) Koller, dr. Th., op. cit., p. 104.

Cakes. — Among these residues in the extraction of oil from seeds, there are some which, not being suitable for feeding livestock, are used as fertilisers. Obviously, spoilt feeding cake which cannot be fed to stock can be used as manure. But as the cake is generally mouldy in this case, it should not be directly applied to the soil; it is better to mix it first with farmyard manure or to incorporate it in composts.

Cakes unfit for feeding livestock are those of castor-oil, bitter almonds, belladonna, mustard, camellina, etc. They are all rich in nitrogen (4 to 7 %) and also contain considerable quantities of phosphoric acid and potash. Owing to the residual oil which they always contain they tend to go mouldy and, if applied in that condition to the soil, they may injure young plants. This is why they are used in the manner indicated above, or else they are spread in advance, before sowing, so that they may have time to decompose.

To facilitate their decomposition, especially in compact soils, they may be mixed with quicklime ($^1/_6$ — $^1/_5$) after being thoroughly ground.

In the United States cotton cake is one of the fertilisers most used for adding nitrogen to the soil. In the dry state this residue contains 5 to 8 % of assimilable nitrogen and small quantities of phosphoric acid and of potash.

It is used especially in the Southern States where 325,000 tons were used in 1914 by manufacturers of fertilisers, besides a considerable quantity used direct by farmers.

The amount of cake to apply per acre varies, of course, according to the kind: as a rule from 324 to 405 kg. per acre are used but as much as kg. 800 to 1 m. ton may be used for the most exacting crops.

Plickly seed-cases of chestnuts. — In places where the chestnut tree covers large areas these seed-cases of the chestnut can be collected in considerable quantities. They can be used by themselves but it is better to mix them first in the dung heap, or else, if transport is difficult they are burned and the ashes are used.

Empty pine cones. — These are the cones of the Stone pine (*Pinus pinea*) which in certain regions forms extensive forests as for example near Pisa, but the cones, with seed or empty, of other coniferous trees should also be included among them.

Generally they are used for fuel, as they burn very well; their ashes, therefore, may suitably be used for manuring.

Residues of starch factories. — These are the pulp of potatoes remaining after the extraction of the starch, or else the residues of seeds of cereals after the starch has been extracted from them.

When these residues are fresh (and it is always desirable to have them fresh) they are used as food for livestock, but they deteriorate very quickly, and are then used for manuring. They are very watery, which makes their transport to a distance difficult. According to Wolff, they contain: — moisture 80.6 % — nitrogen 0.13 % — phosphoric acid 0.05 % — potash 0.03 %. They are consequently a poor fertiliser.

Apple pomace. — This also is used as manure, specially in mixture with farmyard or poultry yard manure. If it is desired to use it directly it should be mixed with calcareous earth or with quicklime in moderation to neutralise its acidity and to facilitate the decomposition of the ligneous matter.

Used tea leaves. — As the British army produced about 600 tons of used tea leaves a month, the Military Administration thought that they might be used for the extraction of caffeine ; but they had to report that it was profitless.

The best way of making use of this material is to put it in composts (1).

Cotton refuse. — The waste of the spinning factories. It is a rather poor fertiliser, containing 1 to 1.5 % of nitrogen and 0.4 to 0.5 % of phosphoric acid. Its most advantageous use is as absorbent material for human excreta. It is also suitable for mixing with farmyard manure or for incorporation with composts (2).

Cocoa pods. — Can be used as fertiliser in quantities of 890 kg. per acre with 133 kg. of basic slag or superphosphate and 45 kg. of chloride of potassium.

Dust and residues of tobacco. — If the habit of taking snuff was as common today as it was in the past, there would be no reason to consider as a residue the tobacco dust which is obtained by sifting the cut rolls of tobacco for consumption, but at present, especially in warm countries, snuff is not used. Thus, for example, in the Island of Reunion (3) large quantities of tobacco dust had accumulated in the storehouses.

At the instance of A. Barau this residue has been tried as fertiliser for sugar-cane with very great success. Tobacco powder was placed at the bottom of the trench at the time of planting, between the cuttings.

The following is the composition of this residue according to an analysis made by M. Garola : — % moisture 11.2, ash 19.2, organic matter 69.6, nitrogen 2.72, potash 3.52, phosphoric acid 0.99, sulphuric acid 0.72, nicotine 0.96. This product may be considered also as an insecticide, at least for grey worms, slugs and snails.

The principal advantage of this matter as fertiliser is that although its nitrogen is non-nitrifiable, and its phosphoric and sulphuric acids are negligible, it supplies potash at a much smaller cost than that of salts purchased (at Réunion) last year.

A second advantage is that, mixed with nitrate, sulphate of ammonia and phosphated manures, it provides more bulky nourish-

(1) Koller, dr. Th., op. cit., p. 845.

(2) From information received from 1 July 1917 to 30 June 1918 from 506 cotton mills in sixteen States of the U. S. A. it appears that two thirds of the cottonseed meal is used as feed and one third as fertiliser. For the period indicated the quantity sold as fertiliser was 444,530 tons (short) over and above the total quantity of meal and that of cake produced was 1,616,617 tons. Cf. *United States Dept. of Agr., Bull.* No. 797, Washington, 1919.

(3) Cf. *Revue Agricole de l'Ile de la Réunion*, No. 10, St. Denis, 1921.

ment to the roots of the canes than pinches of fertiliser often confined to a single point at the foot of the cane shoots.

Besides the powder, the stalks, midribs of the leaves and other residues unsuitable for manufacture are used. In the stalks the nitrogen varies between 2 and 3 %, of which ½-⅓ is in the nitric state. The phosphoric acid varies between 0.5 and 1 % and the potash between 5 and 10 % (1).

It has been noticed that the preparation of tobacco extracts and the extraction of nicotine from residues involves the loss of considerable quantities of fertilising material which pass in solution into the water which is essential for such extraction in all the different methods of manufacture recommended. It is advisable however to recall that tobacco takes from the soil considerable quantities of potash (more than 40 kg. an acre), of nitrogen (more than 20 kg. an acre), and of phosphoric acid (2.83 kg. an acre), so that it is always an advantage to restore these residues to the soil entire.

As soon as the nicotine is extracted from solution by means of alcohol or ethers, it seems possible that the residue which has been already concentrated by certain processes (*e. g.* the SCHLOESING) could be added to the solid part with the water drained off and dried by artificial or sun heat, and then the whole used as an organic potassium nitrogenous manure.

When this is not possible, especially not economically possible, it might be possible to make use of these fertilising substances by placing the solid residues on the manure heap or on the soil heaps, and the liquid residues of the extraction of the alkaloid might be used, on farms in the neighbourhood of the factory, either to soak the mass of the manure, or to combine with the oozings, or to soak the moulds (2).

(1) L. L. VAN SLYKE, Fertilizers and Crops. New York, Orange Judd Co., 1919, p. 285.

(2) The Italian Tobacco Administration has put on the market a short time ago, at L. 30 a bag of 10 kg., *Nicotinous residues of tobacco*, made of morsels and coarse powder of Kentucky tobacco, unsuitable for consumption and soaked with tobacco extract.

These residues according to the Administration have a power of destroying insects little short of that of extract of tobacco at 5 % (Ulex), and an insecticide can be prepared from them on the farm by treating with hot water (4 to 5 vol. of water to one volume of powder) for 8 to 10 hours.

The liquid is filtered through cloth adding cold water and squeezing the solid residues all the time. These latter may be used as a fertiliser, but it is not of much value, as the process described has taken all the goodness out of them. The solution easily spoils and should be made each day.

It remains to be seen whether farmers intending to make use of the insecticide property of tobacco will not prefer the convenient use of the concentrated extract to that of these residues which require a special treatment.

In the United States from 1917 onwards there was manufactured a nicotine insecticide powder, called " Nicodust " or " Nicosulphur ". It is obtained by mixing the powder of tobacco residues reinforced by the addition of " Black Leaf 40 ", or concentrated extract with 40 % of sulphate of nicotine, with a suitable excipient, such as sulphur, kaolin, slaked or quick lime, carbonate of calcium, chalk, ground up fossils, talc, etc. The mixture is dried and reduced to a very fine powder which is dusted on to the plants attacked by insects. To increase its effect nearly all spraying materials and insecticide powders mix well with it (Cfr. R. E. SMITH. The preparation of Nicotine Dust as an Insecticide. *Coll. of Agr., Agr. Exper. Stat. Berkeley, Cal., Bull.* No. 336, Nov. 1921).

Grain damaged by fire. — The Texas Agricultural Experiment Station tried as a fertiliser grain taken from an elevator that had caught fire and was therefore fire and water damaged (1). This grain was steeped and used in such quantity as to add 0.1 gm. of nitrogen to every 5 kg. of earth. It appears that this nitrogen had little value as a fertiliser.

6. — Residues of sugar refineries (2).

Leaves and root-collars. — Used as fertiliser and as forage (see p. 102) Every 50 tons of beetroot produced give almost 25 tons of leaves and collars containing about 270 kg. of potash, 97 kg. of lime, 78 kg. of magnesia, 63 kg. of phosphoric acid and 95 kg. of nitrogen.

Root washings. — Contain earth, small pieces of roots and matter in solution. Can be used for irrigation, but if there are regulations which require them to be purified, they should then be collected in receptacles and treated with perchloride of iron and then with slaked lime. A calcareous mud is thus obtained rich in fertilising matter. 17.1 kg. of perchloride and 215 litres of slaked lime should be used per 1000 hl. of the rootwashings.

Beet pulp. — These are the immediate residues obtained from the extractors after removing the sugar from the slices which contain it. They are mainly used as food for livestock (see p. 163), either fresh or dried, but when they are affected by putrid fermentation they are sometimes used as manure.

But it should be noted that, even when well compressed, they always contain a large amount of moisture which makes their transport to a distance uneconomical, all the more so as their fertilising value is very small. Their most suitable use as manure consists in making composts, rather than direct application.

Scums from carbonatation. — These are in the form of cakes obtained by pressing the calcium carbonate which is precipitated in the state of organic combination with the impurities of the sugary juice when there is added to it for that purpose milk of lime in the proportion of 2.5 to 3 % of CaO.

During precipitation by the lime, pectic matter, coagulated albuminoids and phosphoric acid are also precipitated. In the scum, the lime occurs as carbonate and also partly in a free state.

The chemical composition of the scums resulting from the manufacture of beet sugar varies round the following percentage figures:

(1) G. S. Fraps. Availability of Some Nitrog. and Phosph. Material, *Texas Agric. Exper. Stat. Bull.*, No. 287, Brazos County, Texas, Jan. 1922.

(2) Cf.: 1) I. Fritsch, op. cit. — 2) A. Bruttini, op. cit. — 3) C. Formenti, *Residui agricoli*, Milan, Hoepli. — 4) W. E. Cross, *Los subproductos de la industria azucarera*, Buenos Aires, 1917. — 5) *Journal of the Society of Chemical Industry*, Vol. XXXV, Nos. 6 and 8, 1916 and Vol. XXXVI, No. 7, 1917. London. — 6) P. Razous, op. cit. — 7) De Sornay, in *Comptes rendus de l'Académie d'Agriculture de France*, Vol. V, No. 28, Paris, 1919. — 8) Stohmann-Rümpler-Neppi. Manuale per la fabbricazione dello zucchero. Un. Tip. Ed. Tor., Torino, 1902.

nitrogen 0.3 to 0.8 — phosphoric acid 8.8 to 1.5 — potash 0.1 to 0.5 — lime 15 to 30 — magnesia 0.8 to 1.5 (MÜNTZ and GIRARD). For cane sugar factories the nitrogen reaches 2 % of the dry material, phosphoric acid is found chiefly in the form of a soluble citrate, organic matter is as much as 50 to 70 %. From a series of 7 analyses of this residue, reported by W. E. CROSS, we take the following averages : phosphoric acid 5.43 — nitrogen 2.08.

This residue is collected in filter presses in the form of cakes of lime which when washed do not contain more than 0.6 % of sugar. They represent 12 to 14 % of the weight of the beets and about four times as much of the quick lime employed. This is a very good lime fertiliser and nitrifying agent and it is convenient to use it on land near the factories as transport to a distance is not economical. It is dusted on dry and usually in the summer. The dose is usually 6 to 8 tons per acre or more, especially on clay soils and it is suitable for plants after weeding or for leguminous forage crops. It can also be put with compost.

Diffusion liquors. — These are liquids which are obtained by separation of the crystallisable sugars and of the molasses ; they contain considerable quantities of nitrogen and potash, mostly as nitrates. They are used directly for irrigation, but often they are evaporated to 40-45° Baumé, to crystallise out these salts, which are used as fertiliser (1).

Waste liquids and sediment in the separators. — By a patent of E. HERZKA of Arecibo, Porto Rico, these liquids are concentrated to 55° Brix and treated with sulphuric acid added in quantity equivalent to the total amount of lime and alkalis contained in the liquid ; superphosphates, animal refuse, sawdust are then added and the whole is dried.

In this kind of operation the most important item is naturally the cost of concentration of the liquid. In hot climates (cane sugar factories) evaporation can be effected in the open air in large basins, but in temperate climates (beet sugar factories) this is not feasible.

The calcareous sediments of the separators are used for manuring like the scums. They contain, on the average :— moisture 48.56 % — nitrogen 0.16 % — lime 22.53 % — potash 0.02 % — phosphoric acid 0.50-1 %.

Sediment remains in the filter-press in the proportion of about 4 kg. per kg. of lime used. Almost 10 kg. of sediment in obtained from 100 kg. of beetroot. These sediments are used in composts, or dried in the air and then pulverised for scattering broadcast (2).

Animal charcoal. — This is bone charcoal rendered inactive by repeated use and thus valueless for sugar refining. It is well known that bone charcoal placed in contact with a syrup containing impure

(1) Cf. ALLEN ROGERS. *Industrial Chemistry.* D. Van Nostrand Co., N. Y., 1921, p. 890.

(2) In certain places of British India *the refuse of indigo vats* is used as a manure : this contains 4.20 % of soluble mineral matter with 1.84 % nitrogen, 0.36 % phosphoric acid, 0.28 % potash. Cf. *Dept. of Agric.* Madras, Vol. III, Bull. No. 65. Madras, 1912.

sugar, that is to say as it comes from the sugar factory, fixes the colouring matter and other matter in the sugary solution so that the sugar can be produced in perfectly white crystals.

The use of bone charcoal as fertiliser is of long standing (PAYEN, 1820) especially on land near the refineries. It contains 40 to 65 % of tricalcic phosphate and 1.5 to 2 % of nitrogen. It is consequently a good phospho-nitrogenous fertiliser, but, owing to the state of combination of its phosphoric acid, its action is much slower than that of basic slag and still slower than that of superphosphates. Its action may be facilitated by placing it in heaps which are made to ferment.

It is spread in autumn in the proportion of 250 to 300 kg.: an acre.

According to SOREL, the scum which is formed when animal charcoal is added to the coloured syrup contains :— moisture 35 to 38 % — tricalcic phosphate 50 to 60 % — nitrogen 2 %. It is a good fertiliser, especially for poor acid soils.

Molasses. — Considering the high cost of sugar, and consequently of molasses, and the fact that sea and land transport are once more possible, as they were not during the war, it appears that the most rational use of molasses is for feeding livestock. Nevertheless, some methods of using molasses as fertiliser were investigated and recommended during the war and will be here described.

Experiments made at the Laboratory of Agricultural Research at Port-St-Louis (Martinique) have shown that molasses can be conveniently used either by mixing them with farmyard manure or with defecation residues and ashes so as to form a compost called "*saccharogène*", or else by spreading them in the trenches in sugar-cane plantations or between the lines. With such procedure an increased yield of from 5 to 10 % has been obtained.

A fertiliser has been made in Germany with the residues of molasses by WILKENING's method and a production of 350,000 tons of it a year was counted on. This method consists in mixing the molasses with peat dust and inoculating with *Azotobacter* which decomposes the betain and causes the mass to lose its viscosity. The fermented product contains about 25 % of moisture, 3.75 % of nitrogen, 9.75 % of potash and 45 % of humus, and can be very advantageously enriched in phosphoric acid by superphosphate. Manuring tests with this fertiliser have given good results. According to the method of W. P. THOMSON, Liverpool, the molasses refuse is concentrated in a "triple action" to 44° B, and 30 to 50 % of its weight of bone meal, or mineral phosphate, or guano is added. The mixture is treated with sulphuric acid at about 66° B. and a fertiliser containing sulphate of potash, soluble phosphate and nitrogenous matter is obtained. By the patent of S. W. SINSHEIMER of Swink (Colorado, U. S.) the liquid obtained by separating the sugar from the molasses, is heated to about 100° C to precipitate the calcium saccharate, then filtered. The filtrate is treated with combustion gas containing carbonic acid, which precipitates the lime as carbonate. It is filtered and the filtrate is concentrated at low temperature under reduced pressure. It is used as a nitrogenous potassic fertiliser.

Cane-trash and residues of sugar cane. — The residues of sugar cane factories can be used as litter and thus be directly transformed into fertilisers. When fresh they contain perceptible quantities of sugar and can be used as feed, but they acidify quickly and are no longer suitable. If they were peeled their composition would be similar to that of oat-straw, but this is not an operation that pays. Nor do they lend themselves to burial, as then there is nothing to be done but to use them as fertiliser, fermented as they are.

7. — Brewery residues (1)

Brewers' grains. — Generally these are used for feeding cattle, but as they deteriorate easily, they may be used as fertiliser if they are not fit for food. They do not readily decompose in the soil, so it is better not to apply them by themselves, but in composts after fermentation. They are always very moist which prevents their transport to a great distance. They contain, on the average :— moisture 77 % — nitrogen 0.8 % — phosphoric acid 0.5 % — potash, traces. The average quantity to apply is from 6 to 8 tons per acre.

Barley sprouts (*dried malt*). — These are the germs which have sprouted from the grain and swelled during germination. They are generally used as food for livestock, but if they deteriorate good fertiliser can be made of them, after reducing them to powder, containing on the average :— nitrogen 4 to 5 % — phosphoric anhydride 1 to 2 % — potash 2 to 2.5 %.

To pulverise them they may be treated with hot water for some hours and afterwards watered with boiling water acidulated with sulphuric acid (10 kg. of commercial acid per 500 kg. of dried malt). To get 1 hl. of these germs 20 hl. of barley has to be brewed. The average amount to apply is from 300 to 400 kg. an acre. They are scattered broadcast.

Regarding their fertilising power, it should be remembered that 13-14 kg. of dried malt replace 100 kg. of farm manure.

Hop residues. — These are the hop cones from which the lupuline has been removed in the process of heating with the mash.

They are sometimes used directly as fertiliser in light soils, but it is better to make compost of them in the proportion of 40 kg. per 40 kg. of earth mixed with 10 kg. of kainite + 10 kg. of basic slag. The heap is watered from time to time with liquid manure or urine and it is covered with 10 cm. of earth. The hop residue contains on the average : — nitrogen 0.56 to 0.87 % — phosphoric anhydride 0.15 % — potash 0.02 % — lime 0.16 % — magnesia 0.04 %. It is therefore a fertiliser of little value.

Among brewery refuse there may be mentioned *the water in which*

(1) Cf. A. Bruttini, op. cit.

the barley is steeped, which is poor in fertilising matter, but can be used for irrigating the meadows near the brewery (1).

The *exhausted yeast* is dried, treated with sulphuric acid, and after neutralisation with lime, the mass is used as fertiliser.

8. — Distillery residues (2).

Vinasses, or pomace — This name is given to residues from which the alcohol has been extracted by distillation. There are therefore " vinasses " of beet, potatoes, molasses, and grain. The second is the least rich in fertilising elements :— consisting of non-saccharified starch, dextrine, pectic and proteic matter, a little sugar, mineral matter, elements of yeast.

The " vinasses " of molasses, which constitute an important source of production of potassic salts, should be specially mentioned : evaporated in a PORION oven, they yield the crude salt from which the potash salts are extracted by refining.

It is dangerous to use the acid " vinasses " of beet (sulphuric and organic acids) for feeding livestock. They may be spread on the land near the factory by means of gutters, if it does not cost too much to fix them. Any other method of transport is certainly too expensive.

The " vinasses " of molasses containing about 10 % of potassium salts (sulphate, nitrate, chloride, etc.) are concentrated to obtain the salts which are used directly as fertiliser or which are refined. In this process the nitrogen is unfortunately eliminated by combustion.

The sediment of the salts mixed with the *dregs of the vat* is then made into cake for manure, containing %:— nitrogen 3-5 — potash 2 — phosphoric acid 2.

According to WOLFF, the " vinasses " of molasses contain on the average in the dry matter :— nitrogen 3.2 % — potash 9.5 % — phosphoric anhydride 0.1 %. It is therefore a good potassic and nitrogenous fertiliser. For crops sown in spring, these " vinasses " should be spread in winter.

By KOLLER's method, defecation lime is mixed with the " vinasses " of molasses in such proportion as to get a pulp which is dried on a band drier. The fertiliser thus obtained contain all elements required by sugar beet.

According to the process of the " Pecekëer Zuckerraffinerie " at Pecek, nitrogen, principally as ammonia and ammoniacal salts, can be obtained from concentrated " vinasses " of fermented molasses by dry distillation, not over 600° C, and continuous stirring of the mass.

(1) In British India use is made sometimes for irrigating sugar cane of the water from rice mills which contains a large proportion of nitrogen (0,09 ‰), soluble phosphates (0.4 ‰) and potash (1.3 ‰). Cf. *Dept. of Agric. Madras*, Vol. III, Bull,, No. 65. Madras, 1912.

(2) Cf. : 1) I. FRITSCH, op. cit. — 2) MÜNTZ and GIRARD, op. cit., v. 1 — 3) *Journal of the Society of Chemical Industry*, Vol. XXXVI, No. 16. London, 1917.

The utilization of virgin "vinasses" depends on the cost of transport ; on the other hand, concentrated "vinasses" are so viscous that is impracticable to employ them. The only suitable way is to convert them into a pulverulent fertiliser. According to MÜNTZ and GIRARD the chemical composition of various "vinasses" is as follows, in grammes per litre :—

	"Vinasses" of molasses	"Vinasses" of grain	"Vinasses" of beet	"Vinasses" of potatoes	"Vinasses" of Jerusalem artichokes
Nitrogen	1.5 — 3.0	2.5	0.7 — 2.0	1.5 — 2.5	1.20
Phosphoric acid . . .	0.1 — 0.2	2.5 — 4.5	0.2 — 0.8	0.3 — 1.0	0.02
Potash	1.8 — 9.0	2.6	1.5 — 3.0	2.5 — 3.5	2.87

In consequence of this composition the "vinasses" are generally considered as potassic fertilisers.

By a German patent dated 5 June 1913, a non-hygroscopic fertiliser is obtained by heating "vinasses" with superphosphate at 106-108° C until the free bases present have combined with the phosphoric acid and until complete elimination of the moisture and organic acids is effected.

The method patented by W. W. HAUGHEY of New York consists in :— Concentrating the "vinasses", then drying them at about 150° F (65°.5 C) and finally advancing the drying to 370° F (187°.7 C) to render the fertiliser non-hygroscopic, without loss of nitrogen.

9. — Grape residues (1).

This is a fertiliser in common use after distillation, especially if it has been fermented. It is as rich in fertilising elements as far manure, with which it is often mixed, but the best way of making use of it is to make composts by mixing it with quicklime (2 %) or basic slag (4 %), or else, if neither of these two ingredients are to be had, with calcareous earth + 2 % of sulphate of potash. It is heaped, watered with liquid manure or water and the heap covered with a 10 cm. layer of earth ; this compost is turned over twice and is applied in spring. In place of farm liquid manure, an artificial liquid manure can be used, composed of :— water 1 hectolitre, quicklime 1 kg., sulphate of ammonia 2.5 kg. This is applied in the proportion of 30 litres per cubic metre. If this liquid is to be applied to grape residues not completely exhausted, it should be made with twice as much water and then applied in double quantity. Fermentation rapidly becomes active and, after about 20 days, the heap is unmade and then remade again as in the case of the composts.

(1) Cf. : 1) A. BRUTTINI, op. cit. — 2) MÜNTZ and GIRARD, op. cit. — 3) ROOS, L. in *Le Progrès Agricole et Viticole*, No. 44. Montpellier, 1914.

This fertiliser is applied to vines in quantities of 3 kg. per vine ; it is suitable for all soils.

The chemical composition of grape residues is naturally variable. According to WOLFF, it is, on the average, as follows :— moisture 65 % — ash 3.67 % — phosphoric anhydride 0.46 % — potash 1.72 % — lime 0.4 % — magnesia 0.15 % — soda 0.02 % — sulphuric acid 0.18 % — silicic acid 0.38 % — chlorine 0.02 %. According to MÜNTZ and GIRARD the percentage of nitrogen varies between 1.11 and 1.30 %.

When the residues are fresh and still very acid, they can be neutralised with lime or calcareous road dust, but if they are mixed with farm manure such neutralisation is not necessary, for it is caused in the manure heap by the carbonate of ammonia.

10. — Wine lees.

Generally the lees deposited by wine at the bottom of casks are used for the extraction of cream of tartar ; on the other hand the lees of distilled wines are sometimes used as fertiliser. In the dry matter of one of these lees, M. CHUARD found :— nitrogen 3.9 % — phosphoric anhydride 0.8 % — potash 3.8 % To solidify these lees and then to render them pulverulent, they are treated with lime until their acidity is neutralized ; this generally requires 1 part of lime to 12 or 15 parts of lees. Solidification is completed by adding peat or mould to the extent of 20 to 25 %. The lime can be replaced by gypsum heated to powder.

11. — Olive husks and dregs.

Olive husks. — This properly means the base that appears in the new oil left to clear. It is an oily substance resembling black mud, which is separated from the oil by decantation (or when oil is taken out of soap by boiling), after either process it remains at the bottom as a carbonised mass. Its only use is for burning or to be thrown on the manure heap. In the oil manufacturing business however this term (Fr. : *margines* or *marchies*, Ital. *morchie*) is also used to describe the waters of vegetation obtained by olive pressing, usually in a quantity two or three times more than the oil produced, or corresponding to 30 to 40 % of the weight of the olives.

This water is often lost in the channels, after the separation of the oil, but when it is possible to use it as fertiliser close to the oil press, that is very much the best way. There is present an acid solution of albuminoid and saline substances but in very small quantity relatively to the volume. It is necessary first to neutralise its acidity with lime or carbonate of calcium. It may even be used for watering calcareous soils. Prof. SESTINI advised neutralising the acidity in manure pits in which are layers of earth, lime and weeds. If these pits are made round the trees, the advantages of irrigation and fertilising are combined, particularly in localities where there is a shortage of water.

MINGIOLI (1) observes that under this substance a residue collects formed of small fragments of pulp and kernels which have a distinct value as fertiliser if in its turn neutralised. On an average it contains 2.31 % of nitrogen and 0.05 of phosphoric acid.

The above mentioned residues of oilmaking being very poor in phosphoric acid, it is advisable before use to correct this by addition of a phosphatic fertiliser.

From this liquor a residue can be obtained (called *salino* in Italian) fairly rich in potash. According to an analysis made by Prof. F. SESTINI the lees of olive-husks contain :— substances soluble in water 13.57 % — alkaline chlorides 1.57 % — oxide of iron 1.34 % — oxide of calcium 0.56 % — oxide of magnesium 0.12 % — carbonic acid 1.87 % — matter insoluble in water 1.05 %. One hectolitre of olive-husks yield 3 kg. to 3.5 kg. of ash. In Apulia (2), the olive husks yield over 3 kg. of potassic *salino* per hectolitre the average composition of which is as follows : — part soluble in water 80.31 % — phosphoric anhydride 8 % — carbonate of potash 55.15 % — carbonate of soda 2.57 % — chloride of potassium 21.89 % — moisture and undetermined substances 20.39 %. In a refined state this salt contains 69 % of carbonate of potash, 3.2 % of carbonate of soda and 27.27 % of chloride of potassium.

G. L'ABATE calculates that estimating the average production of oil in Italy at 1,600,000 hectolitres, a production of about 6 million hectolitres of olive husks could be counted on, which if utilised fully would yield 15,000 m. tons of *salino* containing 7200 m. tons of potash.

To give some idea of the quantity of potash which might be extracted from the olive husks derived from olives grown in the principal European producing countries, the following average figures are quoted (3) :—

Producing countries	Production of olives in m. tons
Italy 1909-1920	1,129,490
Spain 1903-1912	1,053,980
Greece 1911-1918	771,862 (4)
France 1910-1918	63,232
Total . . .	3,018,564

Estimating that the olive husks represent 35 % of the weight of the olives, this quantity of olives would yield 1,056,497 m. tons.

(1) MINGIOLI, E. Oleificio moderno. *Nuova Enc. Agr. It.*, P. VII. Turin, Unione Tip. Ed., 1901, p. 157.

(2) Cf. L'ABATE G., *Il problema della potassa e l'utilizzazione delle morchie in Italia*. Bari, G. Laterza, ed., 1918.

(3) Cf. INTERNATIONAL INSTITUTE OF AGRICULTURE, Oleaginous Products. Rome, 1923.

(4) Quantity calculated on the average production of oil.

of olive husks which, according to the figures previously mentioned, would furnish 26,412 m. tons of *salino* containing 15,411 m. tons of potash.

Prof. F. GARELLI (1) of Turin has subjected olive husks to concentration in the presence of sulphuric acid, with a view to obtaining crystallisation of the sulphate of potash formed, then the separation of this salt and the absorption of the mother liquid by porous substances to form a complex manure containing organic nitrogen and potash salts : but he was unable to obtain crystallisation of the sulphate of potash.

Apparently the best method of utilising olive husks as manure is that of STOLZENBERG, which consists in concentrating them to a syrupy consistency, then adding superphosphate to it and, when the mass becomes compact and dry, reducing it to a powder and spreading it on the ground as phospho-potassic fertiliser (2).

Dregs from olive crushing. — This is the residue that collects at the bottom of the receptacles into which the olive residues diluted with water are passed to separate the crushed pulp from the stones: these are first deposited, and then these dregs ("*morchione*" in Italian).

Naturally, no great quantity of this residue is obtained, but it is suitable for use in manuring the olive trees on land near the crushing mills. In an examination which I made of the dregs of a crushing mill in Tuscany (3), I obtained the following analytical results :—

Composition of sample of air dried dregs from olive crushing.

Moisture at 150° C	13.192 %
Crude ash	23.018
Organic matter (by deduction)	63.790
Crude cellulose	48.500
Fats	0.491
Total Nitrogen	0.947
Absorbent capacity for moisture	160.21
Reaction	neutral.

(1) Cf. *L'Italia agricola*, No. 10, 1915. Placentia.

(2) From the waters of vegetation or olive husks (*acque d'inferno* or *margines*) produced in olive growing countries in hundreds of thousands of tons, a rapid fermentation gives a yield of about 15 litres of rectified ethyl alcohol per ton, and from the residue of distillation is produced about 3 kg. of ammonium sulphate and 3 kg. of phosphoric acid and potash salts. The half solid residue after these extractions can be distilled and gas and carbon obtained from it. It may be noted that this elaboration is not of economic interest unless it is possible to deal with these waters of vegetation in large quantities. Cf. R. DE MANJARRÈS, *Rev. Vin. y de Agr.*, XLI, No. 4. Saragossa, 1922.

(3) Cf. A. BRUTTINI, Sulla composizione di un Morchione dei frullini, in *L'Agricoltura Italiana*, Year XIX, No. 260. Florence, 1893.

Percentage composition of the crude ash.

Chlorine	0.025 %
Oxide of iron	9.318
» » calcium	11.452
» » magnesium	0.170
» » potassium	0.399
Phosphoric anhydride	0.524
Sulphuric »	0.570
Silicic »	69.585
Carbonic »	5.728
Undetermined matter and loss	2.229
	100.000

It follows that 1 ton of dregs from olive crushing contains :—

Phosphoric acid	kg. 1.20
Potash	» 0.92
Nitrogen	» 9.47

It is evidently a fertiliser poor in potash and phosphoric acid so that it should be supplemented by chemical manures.

Before using it, it is indispensable to ferment it to render it more easily assimilable. If it has, as it may have, acid reaction, a little powdered lime should be mixed with it.

From one ton of diluted residue, 200-250 kg. of moderately dry dregs are obtained.

Olive oil residues (*sanse*) although more suited for use as feed (see p. 159) are also sometimes employed as a fertiliser, especially if they are at all spoiled or have been exhausted with carbon disulphide. They can be mixed with moulds or piled in heaps, or better in pits, mixing in a little carbonate of lime and watering with liquid manure. These moulds thus become enriched and maturing takes place which may go on for some months. The mass is kept damp all the time. To check loss of ammonia it is advisable to cover the mass with a layer of chalk to which has been added a solution of sulphuric acid (20 % acid). Later on the mass is broken up and the acid layer is removed or neutralised either by additions of carbonate of lime, or crushed phosphorites, and then it is mixed with the olive oil residues.

The following is an analysis of olive oil residues according to Wolff: water $^0/_{00}$ 138, ash 27.8, nitrogen 9.6, phosphoric anhydride 2.5, potassium 7.8, lime 6.1. In the ash of the residue, with the olive kernels removed, treated with sulphur, Prof. F. Bracci found % phosphoric anhydride 3.82 ; potash 3.89, lime 12.27.

12. — Tomato residues.

In preserved tomato factories a large quantity of residue is obtained, viz. : the seeds and the skins. These can be used respectively for the extraction of oil and as food for livestock (see p. 178).

When, owing to the large quantities available, long distance transport, deterioration by fermentation, etc., they cannot be so used, these residues may profitably be used for manuring and, in this connection, the results of an analysis made by Dr. GUARNIERI may be mentioned :— moisture 7.47 % — nitrogen 3.85 % — phosphoric anhydride 1.31 % — potash 0.60 % — ash 6.27 %.

13. — Coffee grounds (1).

Since coffee is for the most part used in small quantities, there are no large stocks of this residue available. It is as a matter of fact generally thrown into the household refuse. It is only in large cafés in populous places that quantities of any importance can be had.

This residue is frequently used for manuring pot plants in rooms or garden plants or small kitchen gardens.

Isidore PIERRE found in airdried coffee grounds :— nitrogen 1.85 % — phosphoric acid 12 % or more. It is therefore a good phospho-nitrogenous manure, but it has the drawback that it often attracts ants especially when spread on the surface of the soil. This disadvantage may be obviated by burying it at once at a suitable depth.

14. — Tanning refuse (2).

Besides spent tan, the residues of the pits or vats are obtained under the name of *vat sediment.* This a mixture of hair and lime arising from cleaning and unhairing. One hundred skins yield about 150 kg. nf vat sediment which contains on the average 10.75 % of nitrogen and 36 % of moisture (GIRARDIN).

The other tanning residues are the *scrapings of hides* and *masses of hair*, with 8.75 % of nitrogen.

According to Messrs MÜNTZ and GIRARD the mean chemical composition of two samples of vat residues was as follows :— Moisture 69.5 % — Lime 18.68 % — Nitrogen 0.76 % — Phosphoric acid 0.30 % — Potash, traces.

(1) Cf. : 1) MÜNTZ and GIRARD, op. cit., v. I — 2) A. BRUTTINI, op. cit.

(2) Cf. : 1) J. FRITSCH, op. cit. — 2) P. RAZOUS, op. cit. — 3) A. BRUTTINI, op. cit. — 4) KOLLER, Dr. TH, op. cit. — 5) ALLEN ROGERS, *Practical Tanning*, London, Crosby Lockwood & Son, 1922. p. 665. — 6) WATT, A. *Leather manufacture*. London, Crosbv Lockwood & Son, 1919, p. 455. — 7) BENNETT, H. G., *Animal Proteins*, New York, D. Van Nostrand Co., 1921, p. 268.

The use of these residues is profitable if the transport charges are not too heavy. The following procedure facilitates the nitrification of their nitrogen: placing in heaps and drying, pulverisation, or treatment with steam in autoclaves to obtain a magma suitable for the manufacture of mixed fertilisers or composts which are from time to time turned over and so pulverised.

These residues, owing to the large proportion of lime which they contain, form a good calcareous fertiliser. There are still other tanning residues to be considered as fertiliser (they are actually used in England): *the water in which the skins and utensils have been rinsed*, *the sweepings of the workroom*, *small scrapings from the skins*, run off into reservoirs so as to mix with spent tan and earth which retains the ammonia.

Spent tan. — This should be considered as matter capable of furnishing the soil with organic matter, but not as a fertiliser. The tannin which it may contain when fresh is injurious to vegetation and preliminary fermentation is necessary to destroy the tannin and reduce it to mould. The action of the tannin can be neutralised by mixing the spent tan with farm manure, liquid manure, or urine all of which contain ammonia. The spent tan can also be treated with lime and a little slaughterhouse blood (RODIGAS' method). It is then allowed to ferment for a year and a half.

Another method (DAUVERNÉ'S) consists in watering the spent tan 2 or 3 times with a solution of sulphate of iron, and mixing thoroughly. It is next made to absorb faeces and, after a few months, the manure is fit for use.

The heaps should remain as they stand for a year; the spent tan can then be applied either to grass land, or in horticulture, mixed with the soil or as protective covering for seedlings and transplants or for hot-beds.

It is preferable to apply it dry, scattered by hand or by machinery.

According to PETERMANN the ashes of spent tan contain :— phosphoric acid insoluble in water, 0.01 % — potash 0.012 % — lime 0.36 % — magnesia 0.015 %. When fresh the percentage of nitrogen varies between 0.5 and 1 %.

In Germany and England, spent tan is also used for growing mushrooms, saturated with urine and mixed with fresh dung pellets.

Lastly there is the tanning refuse to be considered, obtained by cleaning the skins before placing them in contact with the tanning material. In a dry state they contain 6 to 7 % of nitrogen in a complex organic form and of very slow decomposition in the soil. The decomposition can be hastened by disintegrating them by steam and lime.

Glue is also made from them.

15. — Retting water from flax and hemp.

When retting is done in streams the substances eliminated by the water are lost in the stream, often to the detriment of the fish. But when retting is done in stagnant water (pools or tanks) this putrid water, in which microbes swarm, has a certain fertilising value if it used for irrigation.

The residues of *scutching* and *breaking* (scutched stems) form a good litter or else may be carried directly to the dung heap.

The quantities of fertilising elements found in this matter, corresponding to 1000 kg. of flax stalks, are, according to WOLFF, as follows (1):

	Potash	Lime	Phosphoric anhydride
Retting water	9.175	4.100	3.400
Scutched stems	0.171	2.050	0.475

16. — Papermaking residues.

By these are meant the washings of the crude vegetable matter and rags and the muddy deposits found in the receptacles where these washings are done. In these air dried residues PETERMANN found (2):

	No. 1	No. 2
Moisture	13.92 %	4.63 %
Nitrogen	0.70	0.47
Phosphoric anhydride	1.68	0.41
Potash	0.34	0.49
Lime	71.68	—

According to L. KERN's German patent, dated 3 January 1914, the highly concentrated washings are mixed with an almost equal quantity of fossil meal (Kieselguhr), so as to get a powder which can be spread. This mixture contains soluble salts of sodium, potassium, magnesium, aluminium, silicates, colloidal silicic acid, which are contained in the impure Kieselguhr, and also nitrogenous matter.

The reaction is more complete if the mixture is made hot. The fertiliser thus obtained is specially suitable for crops rich in silica, such as maize and other cereals, grasses, forage plants, and very suitable for peaty soils (3).

When there are *bisulphitic washings* they can be mixed with 80-95 % of sand or dry earth, the mass is dried and pulverised, then sprinkled on the ground as a disinfectant, containing oils of wood tar etc.

From a recent study of H. VON FEILITZEN (4) on the employment of lime residues from the manufacture of cellulose sulphate as a fertil-

(1) Cf. MÜNTZ and GIRARD, op. cit., Vol. I, p. 542.

(2) Cf. MÜNTZ and GIRARD, op. cit., Vol. I, p. 534.

(3) KOLLER, Dr. TH., op. cit., p. 105.

(4) Cf. *Kungl. Landtbruks-Akademies Handlingar och Vidskrift,* Year 71, No. 7. Stockholm, 1922.

iser, it appears that taking the carbonate of soda due to changes which occur in the organic compounds of soda of the (bisulphite) washing, and treating it with slaked lime, there are precipitated carbonate of calcium, and a little calcium hydrate and calcium sulphate, and traces of sulphur compounds, besides a little sodium hydrate and carbonate. For the 26 Swedish cellulose factories these residues amount to 165,500 metric tons of lime.

This lime when used on lands under barley or mustard proves innocuous even in strong doses : it can be used with advantage on land situated near the factories after it has lain in small heaps exposed to winter cold which reduces it to powder.

17. — Mill dusts and sweepings.

A very complex mixture of mineral and organic matter, containing also variable quantities of weed seeds. Most of these seeds are liable to germinate, but if they are removed, these residues can be used as manure, preferably by incorporating them in composts.

According to MÜNTZ and GIRARD, these residues contain :— 1 to 2 % of nitrogen — 0.5 to 1 % of phosphoric acid — about 0.6 % of potash (1).

18. — Fish offals (2).

The value of these as manure is equivalent to that of slaughterhouse offals : they can only be used as manure.

Fish offals are the heads, intestines, gills and tails of fish of various sizes. They are utilised in several ways :— they are often thrown on the manure heap ; buried in dustheaps ; mixed with human excrements, or with quicklime (1 hl. per 3 hl. of offals) ; or composts are made of them. A more scientific use is the manufacture of nitrogenous superphosphates by mixing the offals with the mineral phosphates before treatment with sulphuric acid. They may be treated like fish that has gone bad with boiling water, removing the oil by skimming or by pressing ; the resulting cake is then dried, pulverised and treated with a little sulphuric acid to make it more assimilable by phosphate of lime.

We will explain in some detail the different methods of treatment of these residues (3):

1. Burying causes loss of nitrogen, generates large quantities of flies, and makes a fetid smell.

2. Sun drying results in pulverization, but there is a considerable loss of nitrogen.

3. Formation of composts, where the residues in question take

(1) Cf. MÜNTZ and GIRARD, op. cit., Vol. I, p. 533.
(2) Cf. : 1) J. FRITSCH, op. cit. — 2) A. BRUTTINI, op. cit.
(3) F. MARRE, in *L'Engrais*, No. 6. Paris, 1922.

three or four months to mature. In Brittany seaweed is added and a mould obtained containing 3 to 4 % of phosphates.

4. By drying after cooking a product is obtained richer in fertilising principles if use is made of steam. The oil is separated by pressure and the remainder dried in the store and pulverised. The powder thus obtained contains 5 to 5.50 % of nitrogen and 35 to 45 % of phosphates.

5. With the LOREAU process the fish residues are put on gridirons to drip : the liquid is collected and concentrated at a low pressure and yields a residue with 1.5 to 3 % of nitrogen. The parts remaining on the gridiron are cooked over an open fire, dried on the store or in an oven and pulverised.

6. *Norway guano* is prepared with residues cooked with steam under pressure and then dried and pulverised. It claims to have 5 to 7.50 % nitrogen.

7. *Phospho-guano* is obtained by treating the fish residues, deprived of oil and gelatine, with sulphuric acid. Thus a fertiliser is obtained with 7.5-9 % of soluble nitrogen and 15-16 % of phosphoric acid.

The "*ressels*", that is to say the salt brought back by the fishermen from the salting at sea, is sometimes used as fertiliser. But it should be used in small quantities, as it often has injurious effects.

The *herring residues*, for example, may contain from 18 to 34 % of salt, which can be removed by several washings with water containing a little lime. They are then dried. According to PAGNOUL, 100 parts of the residue gives in this way 31.78 parts of the washed and dried matter which contains :— nitrogen 1.69 % — phosphoric anhydride 2.14 % — chloride of sodium 3.27 %. In the washings the nitrogen in solution can be precipitated by treating it with perchloride of iron and lime. PAGNOUL obtained a dry residue containing 2.8 % of nitrogen ; 300 kg. of herring residues thus yield about 100 kg. of fertiliser rich in nitrogen and also in phosphoric acid.

Fish manure made in the *Loffoden islands* from herring offals is obtained by drying these offals, except the heads which are treated in special driers, in the air ; it contains 8.5 to 9 % of nitrogen and 15 to 16 % of phosphoric acid.

Whale guano made from whale-fishery offals is similar to fish manure. It contains up to 13.82 % of fats, which probably retards the utilisation of the nitrogen. The flesh of whales caught in the African seas is treated for extraction of oil, then dried, first in the sun and afterwards in rotating ovens heated with coke with a through draught of air. Then the flesh containing only 10 % of water, is pulped and put into bags and sold to the South African farmers.

The bones are also used to make whale guano and a product with a very small percentage of fat is obtained.

In *Brittany* fishery offals are treated with sulphuric acid at 53° B up to ⅓ of the amount of dry matter, finally the whole is dried in the sun or in an autoclave.

In *Italy* considerable quantities are produced of a manure, called "*bàgano*" in Sicily, composed of the offals of the "*tonnare*" (depots for fishing and curing tunny-fish). According to Prof. CUGINI's analyses this manure contains:— nitrogen 3.72 to 4.28 % — phosphoric anhydride 8.21 to 11.02 %.

In the *United States*, the following procedure is followed (1):—

The offals from the tinning of salmon at Puget Sound (Columbia River territory), and in the south-east and west of Alaska, amount to 25-50 % of the original weight of the fish. The heads are the portions richest in oil and the eggs the richest in nitrogen.

The treatment used for converting these offals into manure consists in: 1) cooking with steam in vertical cylinders; 2) subjecting the mass while still hot to hydraulic pressure; 3) forming cakes which are then dried by steam. The matter so treated contains:— moisture 4 to 5 % — nitrogen 7.5 to 9.5 % — phosphoric anhydride 5.5 to 12 % — oil 8 to 20 %.

It is also recommended as food for livestock.

It has also been proposed that the factories which treat the giant seaweeds ("kelps") of the Pacific coast should make a manure by mixing the treated seaweeds with these fish offals.

The importance of the production of these offals in the United States is apparent from the following figures (2):—

The average production of fish during the 8 years 1910-1917 was 500 million fish; and the offals collected in the preserving factories included 60,000 tons of "scraps" (solid offals) and 85,000 barrels of oil. The record was reached in 1903, when about one thousand million fish were caught (called "menhaden", *Brevoortia tyrannus*). The "scraps" contain on the average 8 % of nitrogen and as much phosphoric anhydride. Their total production in 1916 was rather low:— 27,000 tons.

Together with these fish offals, called also "fish guano", may be ranked birds' guano and bats' guano. These residues of animal digestion exist, the former in large beds now to a great extent exhausted, the latter in caverns in Sardinia, Calabria, the United States, Spain, Hungary, etc., but have not the industrial character which attaches to the residues suitable for inclusion in this work.

19. — Slaughterhouse offals (3).

Among these residues, *blood* occupies an important place and is used as fertiliser either fresh (mixed with other organic manures or alone) or else coagulated with ferric sulphate or quicklime, or dried

(1) Cf. TURRENTINE, J. M., in *U. S. Dept. of Agric., Bureau of Soils, Bulletin* No. 150, 1915, No. 2, 1913. Washington.

(2) Cf.: 1) *U. S. Dep. of Agric., Yearbook*, Washington, 1917, p. 256 — 2) *The Modern Fertiliser*, No. 10. Philadelphia, 1922.

(3) Cf.: 1) A. MÜNTZ and A. GIRARD, op. cit. — 2) A. BRUTTINI, op. cit. — 3) E. POHER, and P. RAZOUS, *Les déchets et sous-produits d'abattoirs et de boucherie*. Paris, Dunod, 1908.

and pulverised. Coagulation is effected also in iron vessels with steam applied below. The coagulum is separated from the serum by filtering under pressure and is then dried by suitable apparatus. The clotted mass obtained is pulverised and bagged. The yield in dry blood is according to MARTEL 17 % of this liquid, but it varies according to the kind of animal, state of preservation, rapidity of coagulation etc.

Dried blood keeps pending use in well closed receptables, but under the influence of air and moisture it undergoes putrid fermentation causing loss of nitrogen. It is a good supplementary nitrogenous fertiliser containing on the average: nitrogen 10-13 % — phosphoric anhydride 0.5-1.5 % — potash 0.6-0.8 % — moisture 13-41 %. Dried horse blood is the richest in nitrogen, a percentage of 14.30; that of sheep and cattle are of nearly the same richness, *i. e.* 13.25 and 13.70 % respectively.

Its action in the soil is very quick, because its nitrogen nitrifies readily. It is applied preferably in damp weather, in the proportion of 120 to 320 kg. per acre.

Gut refuse is matter eliminated from sheeps'-gut when strings for musical instruments or small transmission belts are made. It is a semi-fluid substance which is first coagulated and disinfected with sulphuric acid. An easily decomposed fertiliser is obtained from it containing, according to MÜNTZ and GIRARD :— moisture 89 % — mineral matter 0.83 %, — nitrogen 1.51 %.

The *meat* used as manure is from the carrion of animals that have died or been slaughtered on account of disease. During the war especially in Germany, considerable labour was spent on carcases of killed horses with the object of getting hides, fat, bones and meat powder. This has been described in the Part I (see p. 19, 30, 35).

For drying the Berlin PASSBURG apparatus was used, which works in the following manner :— sterilisation in autoclave, crushing between rollers to break the bones, etc., grinding and conveyance by means of a vacuum pump into a vacuum, and completion of drying in a drier (1).

An old method of using the carrion of dead animals, dangerous to health, consisted in burying it at the roots of fruit trees or else, in the case of small animals, placing it in the dungheap. Sometimes lime was used but even this means did not entirely eliminate grave danger of infection, especially of anthrax.

In some large slaughterhouses, meat unfit for consumption is treated with steam in an autoclave for 12 to 14 hours. At the end of that time 3 layers are formed in the apparatus :— the upper layer formed of fat utilisable for soap-making or as lubricant; the middle layer composed of gelatine dissolved in water; the lower layer formed of a

— 4) KOLLER, Dr. TH., op. cit. — 5) H. MARTEL, *L'Industrie de l'Equarrissage*. Paris, H. Dunod et E. Pinat, 1912. — 6) DAVIS D. T. *The modern Packing House*. Chicago, Nickerson and Collins Co., 1921, p. 201. — 7) R. LEZÉ, *Utilisation des Débris des Animaux*, Paris, Ch. Amat, 1914, p. 27. — 8) *Municipal Engineering and the Sanitary Record*, London, 1922, No. 1700.

(1) KOLLER, Dr. TH, op. cit.

mixture of blood and meat : this is dried, by adding sometimes from 10 to 20 % of sulphuric acid, and then pulverised. This matter contains 8 to 14 % of nitrogen, 1.5 to 2 % of phosphoric acid and 8 to 9 % of moisture.

In the process invented by A. GIRARD, the carrion is treated with sulphuric acid at 60° B, cold or hot, in lead vessels ; after 24 to 48 hours it is converted into a thick pulp while the fat collects on the surface. This pulp, still strongly acid, is then used in the manufacture of nitrogenous superphosphate.

Other similar systems are :— 1) BOUCHERIE's system or treatment with hydrochloric acid ; 2) that of treatment with alkalis, cold and hot. Another form of meat fertiliser was made, at least before the war, in considerable quantities in the South American meat-extract factories : the boiled meat was dried, mixing it also with useless refuse, and the whole pulverised. This meat powder called "Fray-Bentos guano" is also used with advantage, as has been noted on p. 190, as food for livestock. According to PETERMANN, it contains :— moisture 9,46 % — nitrogen 5.40 % — phosphoric anhydride 16.88 % — potash 0.47 % — lime 20.60 % — sand 3.03 %.

During the war there was more complete utilisation whether of raw and cooked meat for human food so that the manufacture of this extract had to be considerably decreased.

At Fray-Bentos a special fertiliser was also made by treating the meat powder with sulphuric acid and saturating the mass with lime. According to the mean of 2 analyses made by PETERMANN, that fertiliser contains :— moisture 9.04 % — nitrogen 3.82 % — phosphoric anydride 13.34 % — potash 1.28 % — organic matter 49.72 % — mineral matter 41.23 %.

Meat powder is a fairly quick-acting fertiliser, but a little slower than that of blood. It is generally applied in autumn in the proportion of from 120 to 400 kg. per acre.

In Norway the flesh of seals and whales is treated in the above way and is sold under the names of "seal guano" and "whale guano". According to L. MACADAM, the latter contains :— moisture 5.6 % — nitrogen 7.6 % — phosphates 29.7 % — carbonate of lime 12 %. Where the consumption of rabbits is fairly large there are considerable quantities of refuse composed principally of the ears, scuts and paws. These residues contain 10-12 % of nitrogen and small quantities of phosphate. In England it is known commercially under the name of *rabbit flick* ; in 1918 it was quoted at £6 a ton (1).

The *residual waters of the slaughterhouses and of the knackers' yards* contain in suspension and dissolved considerable quantities of fertilising matters but may spread germs of infection, especially the water from the knackers' yards. These waters must not therefore be directly discharged into watercourses.

Their chemical composition is very variable. For example the following analysis of BEZAULT may be quoted in milligrammes per

(1) H. J. SPOONER, Wealth from Waste. London, G. Routledge & Sons, 1918, p. 227.

litre : matter in suspension 4,000, fatty matters 1,200, dissolved matter 5,150, mineral substances 430, dissolved organic material 4,770, nitrogen of ammonia in NH^3 (salt or free) 67.3, albuminous nitrogen in NH^3 510.

For the purifying of these waters there are the following methods:

1. Chemical treatment by sulphuric acid, phenol, quick lime, calcium chloride etc. : but this cannot be fully relied on.
2. Concentration by evaporation, but the process is costly.
3. Sterilization by heat.
4. Treatment with peat to absorb the gas and fetid substances. After this treatment a considerable reduction is noticeable in the dry residue (*e. g.* from 500 to 15.4), of the total nitrogen, both the ammoniacal (57 to 3) and the organic. Thus reduced it keeps better than at first, without giving off bad odours.

Meanwhile the turf has acquired a by no means negligible value as fertiliser : *e. g.* residue 57.6 %, ash 3.76 %, lime 0.19 %, potassium 0.35 % phosphoric acid 0.21 %, total nitrogen 4.28.

20. — Bones (1).

These were used at one time powdered as a direct phosphated fertiliser, especially in soils rich in humus where their effect was more immediately obvious, but since the invention of the process of manufacture of superphosphates from bones and minerals and the utilisation of considerable quantities of basic slag from smelting, the direct use of bones may be said to have come to an end almost everywhere.

During the war, the bones from slaughterhouses, from the factories where horses killed in the war were dealt with, and from household refuse, were carefully collected, especially in Germany ; and it was thus possible, though only to a small degree, to supplement the lack of phosphorites, which had to be imported from over seas, for the production of superphosphates.

Fresh bones which have not been subjected to any treatment contain on the average :— phosphoric anhydride 20 % — nitrogen 5.6 % — fats 6-12 % — carbonate of lime 4 %. To render these bones suitable for the manufacture of superphosphates, it is first of all necessary to deprive them of their fat, which serves for soap making and as lubricant ; they still contain the nitrogenous matter or ossein, and mineral compounds are found in them, on the average, in the following proportion :— moisture 6-10 % — phosphoric anhydride 20-30 % — potash 0.2-0.3 % — lime 30-32 % — magnesia 1-1.5 %.

When a farmer has a certain amount of bones at his disposal he cannot do better than sell them to a superphosphate factory and purchase that fertiliser, nitrogenous if made from bones or non-nitrogenous if made from phosphorites, for his own land.

A bone residue produced in considerable quantities in button,

(1) Cf. A. Bruttini, op. cit.

comb, etc., factories is *bone raspings*, which may contain up to 54 % of tricalcic phosphate and 3.2 % of nitrogen.

Bone ash, the mineral residue from the calcination of bones, is produced in considerable quantities in South America. It contains about $^4/_5$ of phosphate of lime and is used for the manufacture of superphosphates, like phosphorites. In conclusion, it is noted that at the present time farmers very seldom use bones directly as manure, because they sell them to manufacturers of glue and bone superphosphate. This subject thus properly belongs to that of chemical manures.

21. — Animal glue and lard residues (1).

Nitrogenous fertilisers, containing 3 to 4 % of nitrogen formed by the cutaneous, or tendinous parts, débris of muscles, etc.

They can be used by mixing them intimately with 25 % of sulphuric acid at 52° B. The pulp is then mixed with earth, plaster, animal charcoal, etc.

These are rather slow-acting fertilisers, not very easy to apply if they contain much moisture, but they may be rendered dry by mixing them with dried peat, or with sawdust, wheat chaff, clay soil; they may also be mixed with farm manure.

According to Prof. F. Sestini's analyses, these residues have the following percentage composition :— moisture 46 — organic matter 33.5 — mineral matter 20.5 — nitrogen 3.042 — phosphoric anhydride 0.03. Senator N. Passerini found :— moisture 56.676 — solid matter at 105° C 45.324 — organic and volatile matter 30.936 — crude mineral matter 14.388 — nitrogen 2.627 — phosphoric anhydride 3.633 — lime 7.714.

The quantity to use per acre is from 200 to 280 kg. ; it should be applied in autumn.

Residues similar to those just mentioned are those of *lard* or *tallow* or *beef fat*, etc., formed by membranes or aponeuroses together with a little blood, fat and splinters of bone which are obtained as residue in the extraction of tallow.

According to Boussingault and Payen the lard residues contain 11.87 % of nitrogen, whereas according to Müntz and Girard they only contain 5.5 % of nitrogen but 2 to 3 % of phosphoric acid. They therefore form a good nitrogenous fertiliser, but rather slow in decomposing.

They are applied early, in autumn, in the proportion of 360 to 400 kg. per acre. As they are generally sold in compressed cakes, they should be chopped up and kept steeped in hot water before applying them. They are often mixed with composts and the whole applied after a certain time.

(1) A. Bruttini, op. cit.

22. — Dairy residues.

As has already been stated when dealing with food for livestock, it is necessary, in this case, to distinguish between dairy by-products and residues. Among the residues utilisable as fertilisers are the following :—

Sediment of the separators. — This is a deposit which remains in the centrifugal separators to the extent of 0.3-0.13 % of the skimmed milk. With milk from diseased cows or cows that have just calved this residue may amount to 0.25 %.

It consists of a mixture, greenish grey outside and white inside, of solid, foreign matter, remains of fodder and excrements, spores of fungi, fragments of animal cuticular cells, etc. ; the internal white layer is a phospho-caseinate of calcium.

Its chemical composition is variable ; FLEISCHMANN found :— moisture 68.20 % — fat 1.42 % — casein 25.34 % — other organic matter 1.82 % — mineral matter 3.22 %. This residue is very rich in bacteria, among which there are some very dangerous such as those of tuberculosis, typhoid fever, etc.

" It is therefore scarcely necessary to say ", writes M. ROLET (1), " that great care should be taken not to give these sediments to livestock or to mix them with the skimmed milk intended for them. Unless they are buried at once as fertilisers they should be destroyed by burning. This has been made obligatory in Denmark and Germany ".

Residuary liquids. — These are the washings mixed in certain cases with whey, and are most abundant where the dairy work is conducted according to modern ideas of the most scrupulous cleanliness. In fact, in such cases, the quantity of residuary liquids is almost equal to the amount of milk used and, at times, amounts even to twice and a half times that quantity.

These liquids contain, in very variable proportions, albuminoids, fats, lactose, lactic acid, common salt and carbonate of soda. Thus, A. CALMETTE, for example, found in them, in milligrammes per litre : organic matter 1550-2135 — organic nitrogen 43.6-115 — fats 628-1440. Left standing, these liquids quickly begin to ferment with rapid decomposition of the lactose and albuminoids.

Instead of passing these residuary liquids into a stream, they may be poured on land near the dairy, where they will have fertilising value, especially on sandy calcareous soil in which nitrification is more active. To promote this it is desirable to suspend the pouring out of the liquids from time to time. If they contain whey, the acidity should be neutralised with quicklime.

Before using these liquids in this way it is desirable to collect them in a settling tank.

(1) Cf. A. ROLET, Les Industries annexes de la Laiterie. Paris, Baillière, Editor, 1920.

A quantity of 25 to 40 litres per square metre per day should not be exceeded. For large quantities of residuary liquids, attempts have been made to apply various methods of chemical, biological, bio-chemical and mechanical purification.

These processes have their qualities and their defects ; they cannot be dealt with here. But the DAIRE, DORNIE and VIGNEROT process, which consists in adding superphosphate and then slaked lime to the residuary liquids, may usefully be mentioned : a precipitate of phospho-caseinate of lime is thus produced which carries off a large amount of fat ; the clear liquid is then decanted and the precipitate is collected on a filtering layer of peat which is then used as manure.

GERBER *apparatus residues.* — When this apparatus is used at frequent intervals every day to determine the fat in the milk, it accumulates large quantities of a mixture of milk, sulphuric acid and amylic alcohol.

Sometimes this mixture is thrown away on uncultivated land. M. MARÉCHAL recommended pouring it into a pit the bottom of which is covered with a 10 cm. layer of quicklime on which is placed an equal layer of coal ashes, mineral phosphate, basic slag, oyster shells, or bones, etc. The acid renders part of the ashes soluble and produces sulphate of lime, so that a mixture is obtained containing sulphate of lime, alkaline sulphates, etc., which can be used as fertiliser provided all acidity has been neutralised.

23. — Wool and Silk waste (1).

Wool. — These are in the first place various residues which may be collectively termed sweepings of the wool spinning and cloth factories; then all the bits, shearings of cloth, dust from wool-combings, washing residues, etc.

The shearings contain 4-6 % of nitrogen, the dust 2.45-5.20 % ; the sediments from washings contain 0.5 % of nitrogen, 0.12 % of phosphoric acid and 0.28 % of potash.

The waste from shearing the cloth, or "*bourre de laine*" contains according to Senator N. PASSERINI's analyses — moisture 9.588 % — organic matter 82.444 % — mineral matter 7.889 % — fats 16.134 % — nitrogen 5.938 % ; the pure ash analysed contained : — potash 4.508 % — phosphoric anhydride 6.839 %. That writer recommends the use of the shearing waste for olive trees to the extent of 13 lbs. per tree after mixing it with wood ashes, chloride of potassium, basic slag, or also with the leaves and twigs from prunings, also with the olive husks from oil-pressing previously neutralised with lime.

(1) Cf. : 1) A. BRUTTINI, op. cit. — 2) FRITSCH, op. cit. — 3) P. RAZOUS, op. cit. — 4) SCHRIBAUX, in *C. R. de l'Académie d'Agriculture de France*, t. VI, No. 20. Paris, 1920. — 5) E. J. RUSSELL, in *Journal of the Board of Agriculture*, No. 21. London, 1915. — 6) S. J. JOHNSTONE, Potash. *Imp. Inst.* London, J. Murray, 1922. — 7) Wool scouring wastes for fertilizers purposes, in *Amer. Fertilizer*, May 6, 1922, No. 9, p. 57.

The shearing waste can also be applied to vines (1320 lbs. per acre) by mixing it with leafy vine branches, decomposed vine shoots and fermented residues.

For wheat, it is recommended to apply 530 lbs. of shearing waste + 530 lbs. of farm manure per acre, after mixing, heaping and fermentation hastened by liquid manure or urine.

Whatever kind of wool waste is used as fertiliser, it should always be made to ferment by keeping in heaps and moistening with water, liquid manure or urine ; or else mixing with lime and the whole incorporated in composts.

It is also desirable, when possible, to apply industrial treatment with concentrated sulphuric or hydrochloric acid or with steam at 150° C in an autoclave for 7 or 8 hours. A black, friable substance called "*azotine*" is thus obtained, which contains 9 to 12 % of nitrogen.

The treatment in autoclave is applied especially to scraps of cloth containing cotton, preventing their being spun again for the manufacture of inferior cloth.

Prof. SCHRIBAUX states that Dr. A. de ROTHSCHILD observed that the dust of natural wool used as fertiliser is sometimes injurious because it introduces seeds of weeds, such as *Medicago maculata* and *M. denticulata*, which have been found at times in the proportion of 3.8 %, into the soil. One ton of wool dust in that case contains 38 kg. of these weed seeds, of which 22.8 kg, germinate immediately while the rest (hard seeds) germinate after a certain time, thus this trouble lasts for several years. In our opinion, this drawback could be remedied by treating the dust of natural wool with steam at 100° or more or else with boiling water.

Experiments made at Rothamsted have enabled RUSSELL to conclude that wool waste is efficacious for all crops, even on heavy soils. Waste treated with sulphuric acid or well scoured did not appear to have a better effect than the untreated waste.

The scoured residues should be applied in the proportion of 4 ½ tons per acre for maize crops and meadows.

The wool scour contains in solution many other substances in a varying proportion. It carries infection even more readily than sewage, and for this reason its direct discharge into water courses is more dangerous. The fats in it decompose very slowly.

For the purifying of these waters CALMETTE suggests the following methods.

1. Mechanical treatment — stirrings etc. — to oxidise the dissolved matters.

2. Treatment with acids : sulphuric and hydrochloric.

3. Treatment with alkalis : principally lime.

4. Treatment with salts : ferrous chloride, chloride of manganese, ferrous and ferric sulphate and aluminium sulphate, ferruginous phosphate of soda, etc.

5. Treatment by evaporation, with a view to reduction to $^1/_{10}$-$^1/_{15}$ of the original volume. The result is as follows : impure

distilled water, wool fat, raw carbonate of potash (50-70 %), mud and sand. This last method is the most hygienic but is expensive, so that CALMETTE considers the best plan is to purify these waters with chemical re-agents before passing them into the drains.

Silk. — Residues from spinning which cannot be used for textile fabrics ; they contain from 8 to 10 % of nitrogen. They decompose rather slowly in the soil.

24. — Waste from hair, feathers horns and hoofs (1).

Hair and feathers. — Waste of this kind is furnished by cleaners of horse hair, brushmakers, feather dressers, etc. and yields first-class nitrogenous fertilisers (12 to 15 % of nitrogen in a dry state ; 4 to 6 % in a moist condition with impurities), but very slow in decomposing. Torrefaction is necessary or they can be subjected to treatment with lime or mixed in the manure heap or in composts.

An industrial treatment, as is given to wool waste, is steaming at 5-6 atmospheres, or treatment with concentrated sulphuric or hydrochloric acid, or with carbonate, of soda, besides the treatment with lime above referred to.

Residues of horns and hoofs. — Parings, raspings, cuttings, dust from polishing, can be used as fertiliser. These residues also should be baked or treated with steam in an autoclave. They should then be pulverised.

According to MULDER, horses' hoofs contain not less than 16.7 % of nitrogen, the horns of cattle contain 17.1 % of it. The raspings come from the button, comb, etc. factories, the cuttings from shoeing forges.

The fertilising action of these residues is very slow; they are only suitable for woody plants.

Hair. — M. KOLLER (2), states that in 1915 a great collection was made in Germany of women's hair, which was sent to a central depot in Leipzig, where it was washed, scoured and sorted according to length : the longest hair was sold to hairdressers while the rest was used for making long strong belting for machinery, bags for pressing olives, etc. This was in substitution for what was made before the war with Chinese hair, also with horsehair, camel's hair, etc. (3).

(1) Cf. : 1) J. FRITSCH, op. cit. — 2) A. BRUTTINI, op. cit.

(2) Op. cit., p. 167.

(3) The use of hair as fertiliser in China was very ancient. Witness the following extract :— " In certain places, such as the Province of Che Kiang, to improve the crop of rice, they take care, when sowing, to bury pellets of pigs bristles, or even human hair, which according to them, gives strength to the soil and vigour to the rice : those people whose trade is to shave heads collect the hair carefully and keep it until the inhabitants of these places come to purchase it . . ." Cf. : J. B. du HALDE, Description géographique, etc. de l'Empire de la Chine et de la Tartarie Chinoise, v. II. Paris, P. G. Lemercier, MDCCXXXV, p. 64.

25. — Leather waste (1).

This is obtained in all kinds of leather work and contains from 7 to 9 % of nitrogen, but the tanning makes it very resistant to decomposition, so that without preliminary treatment it has no value as fertiliser.

Various treatments are recommended: one being to treat with water containing 5 to 6 % of sulphuric acid, then to roast and reduce to a powder, rendering the whole more porous and friable and consequently more rapidly decomposable. A similar method to the above is the patent of R. P. Rose of Pittsburg: the leather waste is hydrolysed with dilute sulphuric acid in contact with an oxidizing agent (?) in an autoclave under steam pressure of 50 lbs. per square inch.

According to a British patent, the leather waste is steeped and then allowed to ferment. Five parts of fermented waste is mixed with eight parts of phosphate of lime and the mixture is treated with sulphuric acid to decompose the phosphate and convert it into superphosphate, after which it is dried, triturated and the phospho-nitrogenous fertiliser so obtained is placed on the market. According to another patent, that of H. P. G. Lissagaray, the leather waste is immersed for 5 minutes in water acidulated with 10 % of concentrated sulphuric acid, or alum, or sulphate of manganese. It is then air dried and drying is completed with hot air. The substance then becomes friable and easily reduced to powder. These residues can also be used in accordance with Proschwitzky's process by distillation in retorts with alternate layers of 1 part of residue and 4 parts of lime. In the gas given off are found ammonia and crude carbonate of ammonia. The residue from distillation is used as fertiliser.

The Committee of the British Association (2) in 1917 tried to utilise condemned Army boots by dry distillation and absorption of the products by sulphuric acid, and obtained 23-25 % of crude sulphate of ammonia from them.

According to recent unpublished researches by Dr. L. Bonavia on the dry distillation of condemned war boots, only 13.26 % of neutral sulphate of ammonia can be obtained, whereas by dissolving the leather in sulphuric acid a conversion of the nitrogen into ammonia corresponding to 35.2 % of neutral sulphate is obtained (3). It has also been proposed to dissolve this leather waste in sulphuric

(1) Cf.: 1) A. Bruttini, op. cit. — 2) *Journal of the Society of Chemical Industry*, v. 37, No. 8, 1918. — 3) Koller, Th., op. cit.

(2) Cfr. C. Lamb, "The utilisation of condemned Army boots", *Journ. of the Chem. Ind.*, v. XXXVI, No. 18, 1917, p. 986.

(3) Worn out army boots have been chiefly used to obtain "leather gas" which resembles Dowson gas or poor gas. This was done during the years 1919-1920 at Modena utilising the large quantities of boots that had accumulated at Saliceta S. Giuliano. An ordinary tower gas generator is used with injection of water and compressed air under the fumace. The calorific power of the gas comes out at about 1300 calories. Cf. G. Bianchi, Sopra un gas di cuoio distribuito nel dopo guerra alla città di Moderna, *Atti della Soc. dei Matem. e Natur. di Modena*, Series V, vol. V, 1919-1920.

acid and then to use this acid for making nitrogenous superphosphate. Rags and wool and leather waste, etc., treated with sulphuric acid, yield a fertiliser which corresponds with 23 % of nitrate of soda.

The moist raw material is treated hot with the acid and mashed. According to the British patent No. 26780 phosphate of calcium should be added to the leather waste.

The mash is passed into a closed tank, the fumes pass into an absorbing tower and the gases which escape from the tower are passed through a peat filter and then into the open air.

The volatile nitrogenous compounds are converted into ammonia by catalysis with alumina heated to a high temperature. The final dried product contains 6-8 % of nitrogen (1). According to the patent taken out by H. DEVOS of Belgium, a fertiliser can be obtained by heating leather waste in an autoclave to about 95° C, with dilute acid or acid salt, carefully avoiding stirring or boiling of the liquid. After 1-4 hours a pulp is obtained which is caused to solidify in slabs and dried in the air, it is then pulverised. The decanted acid liquor can be used again (2).

It has been proposed, and in some cases the suggestions have been carried into effect, to use leather waste from war boots in other ways, such as material for street paving, for making animal charcoal, extraction of fat, artificial leather, glue, etc.

Lastly it should be stated that according to PETERMANN, MÜNTZ and GIRARD leather waste has very little value : among animal fertilisers it stands last.

In all cases when used as fertiliser it is always applied to woody plants, since its action is too slow for herbaceous plants.

26. — Dead insects (3).

Residues from the breeding of silkworms and from other insects such as locusts and cockchafers can sometimes be collected in large quantities.

Silkworms. — The chief material is *chrysalids* remaining after spinning the cocoons ; they contain in a fresh state 2 % of nitrogen, and in a dry state :— moisture 10 % — nitrogen 9.42 % — phosphoric acid 1.82 % — potash 1.08 % (AUBIN). These are used directly as fertiliser, after drying and pulverising, but it is better to mix them in the farm manure heap or in composts. (For food of livestock see p. 198).

The silkworm bed, which results from the mixture of silk worm excrement with the residue of the mulberry leaves, is generally used for feeding pigs, but it may very well be used as fertiliser. It con-

(1) KOLLER, Dr. TH., op. cit., p. 104.

(2) Cf. *Chimie et Industrie*, V. 7, No. 1. Paris, 1922, p. 148.

(3) Cf. : 1) A. BRUTTINI, op. cit. — 2) *Revista de la Asociación rural del Uruguay*, Year 47, No. 7. Montevideo 1918. — 3) SCHUGURENSKY , L., *Revista del Centro Estud. de Agron. y Veter. de la Univ. de Buenos Aires*, Year 13, No. 99. Buenos Aires, 1920.

tains, in a dry state :— moisture 12.96 % — ash 13.74 % — carbonate of lime 4.21 % — phosphoric acid 0.55 % — potash 3.28 % — nitrogen 1.63 %.

Locusts, especially now that the measures of control have been strengthened in many of the invaded districts, are sometimes collected in enormous quantities and are used for manure. Thus, in Uruguay, according to a Report of the Commission of the Ministry of Industry on the use of captured locusts, these insects were first dried in ovens made for the purpose, then in the sun.

For the "langosta saltona" (wingless insect or cricket) thus treated the following analytical results have been obtained : moisture 8.93 % — total dry matter 91.07 %. In the air dried matter there was :— ash 0.73 % — lime in the ash 0.32 % — acidity expressed in acetic acid 3.19 % — fats 9.39 % — nitrogen 10.28 % — total proteids 64.25 % — digestible proteids 38.94 % (1).

In Argentina during the 3 campaigns 1916, 1917 and 1918, 289,221,850 kg. of "saltonas" (crickets) were captured as well as about 39 million kg. of locusts both just hatched and fully developed. Calculating that about 30.000 tons of them could be used a year, fat and fertiliser to a value of 6 million francs a year might be recovered from them.

The dried locusts, as has been previously mentioned, are used as food for livestock, the nutritive value being equal to that of oil cakes. This is specially suitable for fattening pigs and cattle, but is also accepted by sheep and horses.

Locusts with the fat removed are suitable for manure and in this respect are better than dried blood and meat powder. The fat extracted from them is a good lubricant.

Cockchafers. — In certain years these are so numerous that enormous quantities of them are collected. According to MÜNTZ and GIRARD they contain, when fresh : 3.2-3.5 % of nitrogen — 0.6 % of phosphoric acid — 0.5 % of potash. In the dry matter the percentage of nitrogen amounts to 12-14 %.

(1) The analyses made by MÜNTZ and GIRARD (*Les Engrais*, Vol. II, p. 209) are here reproduced :—

	Locusts		
	Fresh	Dry	Dried and fat removed
Nitrogen	8.47 %	11.36 %	14.00 %
Phosphoric anhydride	1.50	2.03	2.50
Potash	0.96	1.30	1.60
Lime	0.91	1.23	1.52
Moisture	26.00	—	—

27. — Potash extracted from various industrial residues and from ashes (1).

In discussing the utilisation of animal and vegetable residues there has been occasion to note the utilisation of their potash. Special reference must now be made to the potash contained in considerable proportions in certain industrial residues. The large quantities of these residues together with the great need during the war for potassic salts induced experimentalists to improve the processes of extraction and the various States to aid and encourage their use. Not all the processes adopted during the war have in consequence continued in use but some of the improved processes may be considered as permanent addition to the industry of the production of potassic salts other than from mines.

Potash from the brine of saltworks. — It is known that the brine in the crystallisation basins of common salt contains chloride of potassium. At different times (Balard in 1826), attempts have been made to extract this fertilising salt from the brine, but never with economic advantage, mainly because of the competition of German potassic salts.

During the war the German potassic salts were no longer available and research concerning the utilisation of brine from saltworks was renewed: in Italy the "Amministrazione delle Privative» (Administration of Monopolies) undertook in 1916 a series of researches on this subject in the Government saltworks in Sardinia.

The volume of brine obtainable for all Italian saltwork, at 32°.4 B, amounts to 506,774 cubic metres. For the Sicilian saltworks (non-State) it is calculated that each ton of common salt extracted corresponds to 0.870 c. m. of brine, containing, on the average, 9.06 gr. to 22.51 g. of potash per litre. But in a brine at 31°.4 B. from the Trapani saltworks, M. Levi found 15.585 gm. of potash, equivalent to

(1) Cf.: 1) Levi, M. Min. Ind. e Comm. *Atti del Com. per l'Ind. Chim.* Rome, 1917. — 2) Manzella, E. *Ann. di Chim. appl.*, v. VII, No. 1-8, Rome, 1917. — 3) Nishimura, T. *Journ. of the Chem. Ind.*, v. XXXVI, No. 19. London, 1917. — 4) P. Razou, op. cit., p. 88 and 526. — 5) Cranfield, H. T. *The Journal of the Board of Agric.*, v. XXIV, No. 5, London, 1917. — 6) Anderson, E. *The Journ. of Ind. and Eng. Chem.*, v. 9, No. 7. Easton, Pa., 1917. — 7) U. S. Depart. of Agric. Yearbook. Washington, 1916 and 1917. — 8) Söderbaum, H. G. *Kungl. Landtbrusk-Akadem. Hand. och. Tidskrift*, Year 53, No. 1. Stockholm, 1914. — 8) De Dominicis, A. *Ann. della R. Scuola Sup. di Agr. di Portici*, s. II, v. XV. Portici, 1920. — 9) Couluma, J. *Bull. Agr. de l'Algérie, Tunisie et Maroc*, s. 2, Year 27. No. 4. Algiers, 1921. — 10) Burrel, B. *Chem. News*, v. 112, No. 2907 and v. 113, No. 2949, London, 1915 and 1916. — 11) Ellis, R. H. *Journ. of the Soc. Chem. Ind.*, v. XXXV, No. 8, London, 1916. — 12) Aita, A. *L'It. Agric.*, No. 2. Placentia, 1915. — 13) Russel. S. *The Journ. of the Board of Agric.*, v. XXI, No. 8. London, 1914. — 14) Fritsch, J., op. cit., p. 233. — 15) Davis, R. U. S. Dep. of Agric., *Circular* 61, Washington, 1919. — 16) Hicks, W. B., Nourse, M. E., *Potash in* 1919. Gov. Print. Off. Washington, 1920, with a bibliography of publ. on potash published in the years 1918-1919 and 1920. — 17) Müntz and Girard, op. cit., v. III. — 18) Sorel, E., *La grande industrie chimique minérale*, v. II. Paris, Gauthier-Villars, 1904.

29.719 gm. of chloride. At 30° B. the chloride content would be 25.55 gm. According to this writer, 13,639 m. t. of chloride of potassium plus 1,077 m. tons of bromine could be obtained from the whole of the Italian saltworks (1).

Allowing an annual utilisation of 100,000 cubic metres of brine from the Trapani saltworks, charged at 1 *lira* per cubic metre, E. MANZELLA estimates 400,000 *lire* cost of installation, 900,000 *lire* working expenses and a net profit of 700,000 *lire* a year (2).

Regarding the experiments made by the Administration of Monopolies in the Sardinian saltworks (Cagliari) it appears, that sulphate of magnesium has been obtained, which the Administration uses for mixing with the salt intended for salting sausage skins, and that a considerable quantity of a mixture of salts, among others potassic salts, have since been obtained. This mixture, in spite of offers made to chemical product factories, has remained unused up to the present.

The brines are disposed of to a "lapis-lignum" factory for paving blocks.

The Monopoly experts have concluded from this preliminary experiment that the manufacture of potassic salts in salt-works intended mainly for the production of table salt is of no economic advantage.

From saltworks in the United States, 60,681 *short tons* (of 907 kg.) of crude potassic salts, containing 13,956 m. tons. of potash, were extracted in 1918.

The annual quantity of brine produced by the Japanese saltworks is 240,000 tons ; it contains 2.30 to 3.48 % of chloride of potassium of which 80 % is recovered, thus obtaining a chloride of 80 % purity.

For other saltworks in the world, there are no similar data, but those just quoted make it possible to form some idea of the very large quantity of potash which may be obtained from the brines of saltworks.

Potash extracted from blast furnace dust. — According to GOURY this dust is suitable for use when it contains at least 10 % of potash (K_2O), mostly found in it in the form of salts derived from the original potassic silicates. These compounds, soluble in water in proportions varying from 4.07 to 19.49 %, are principally chloride, sulphate and carbonate of potash.

This dust is deposited in the flues of the boilers heated by the gases of the blast furnaces; they vary in colour and in richness in potash : the richest, a cream-coloured dust, contains according to

(1) For information regarding the Trapani salt-works consult A. BRUTTINI, "Sulle saline trapanesi e sulla lora stima" in *Il Politecnico*. Milan, 1900. Tip. e Lit. degli Ingegneri.

(2) The "*Società Anonima Derivati Acque Marine*" at Trapani (Sicily) has been carrying on since 1921 a manufacture of salts of magnesium, treating the brine of some of the salt works close by. At present only a part of the brine is handled, but it is intended to make use of brine from all the salt-works of Trapani, amounting to about 200,000 cubic metres per annum. In future potash salts will also be extracted ; just now about 4 m. tons of magnesium salts are turned out per day and exported to Milan. The principal uses of these salts, especially the chloride, are the manufacture of magnesium and the preliminary treatment of textiles for the dyeing process.

CRANFIELD from 11.82 to 15.89 % of potash soluble in acids and from 5.69 to 9.25 % of K_2O soluble in water.

That writer calculated that in Great Britain the total annual production of potash from blast furnaces reaches 15,000 tons, of which at least one half is soluble in water. The crude dust, especially the cream coloured dust mentioned above, can be used directly as fertiliser. In the United States, according to W. B. HICKS and R. NOURSE, potash is produced in very small quantities in the blast furnaces.

About 60 % of the potash in the blow pipes of the boilers and in the chimneys is lost. Corresponding to a production of 28-29 millions of tons of cast-iron in the United States there are 85,000 tons of potash. But very little of this is recovered because the greater part remains in the lixiviation water of the gas and a considerable part is dispersed in the atmosphere. In the United States during the war there were recovered in this way less than 500 tons per annum, but with the furnaces on the Cottrell system it was clear that from the end of 1919 from 1000 to 1500 tons of potash could be supplied per annum (1).

Germany and France possessing respectively the large potash deposits of Stassfurt and Alsace have no interest in extracting potash from the blast furnaces.

Dissolved salts of potash are also present in the blast furnaces gas washings which, in the dry extract, vary between 20.6 and 55.7 % with an average of 33.5 %. When these washings can be economically evaporated (for example by means of solar heat and wind as in saltworks), the utilisation of their residue as potassic fertiliser is of interest.

According to K. CHANCE for every ton of cast iron produced in England there goes into the furnace with the minerals an equivalent of 15 to 30 lb. of potassium chloride, so that the total quantity of potash salt going into the furnace annually is about 200,000 tons. Of this quantity under the ordinary conditions of the process about 150,000 tons are lost with the slag and 50,000 tons are volatilised in the form of carbonate, chloride and cyanide, of which $^4/_5$ are given off into the atmosphere. A part of the remaining 10,000 tons is deposited in the chambers with the coarser dusts, while a certain quantity is usually recovered as sulphate in the blow pipes.

The methods for the collection of these dusts may be classed as follows: 1) water pulverization; 2) electric precipitation; 3) dry filtration through bags. This last is the one chiefly relied upon. By this system, called the Halberg-Beth, a dust is collected, having the following percentage composition: bicarbonate of potash 23.23, carbonate of potash 14.66, chloride of potash 10.90, potassium cyanide 5.58, potassium formiate 3.66, p. sulphate 1.13, carbonate of soda 3.97, ferric cyanide 0.48, sulphur of zinc and of lead, 0.36, ferric

(1) A. E. WELLS, Dept. of Fed. Bureau of Mines. *The Potash Industry of the U. S. and its possibilities for future production.* Washington, 1919.

ferrous oxide 11.68, carbonate of lime 10.39, sulphur of zinc 2.23, oxide of magnesium 1.05, carbon 2.18, flint, 8.91. The composition of these dusts is thus very variable.

To make use of the potash which is usually lost in the refuse slag of the blast furnaces and to cause it to pass in fumes so as to be collected as indicated, a proposal has been made to combine common salt with the iron ore so that the base of the salt, viz. sodium, may take the place of potash in the slag and thus volatilise it. On an average for each ton of potash contained in the dust there is needed three-quarters of a ton of common salt.

The quantity of potash which can be recovered from blast furnaces by this use of salt, and by filtration of the gases, rarely falls below 100 lb. of chloride of gas, and in many cases is much more.

Potash from cement factories. — In view of the stoppage of the export of potassic salts from Germany, a scheme was put forward for collecting the potassic salts from cement kilns usually borne away by the draught and dispersed in the air. The precipitation of this very fine dust in deposit chambers is obtained by means of special electric separators. According to researches by Messrs NESTELL and ANDERSON the smoke and dust from cement factories represent about 10 tons of matter lost every day per kiln by the chimneys. That dust is partly composed of calcined raw material, coal ash and alkaline compounds, mainly sulphates and secondly carbonates. The potash in it varies between 10 and 11 %, of which 86 % to 90 % is soluble in water, while the remainder in the form of silicate is insoluble or slowly soluble. (1)

This utilisation of the potash from the silicates contained in the ore introduced into the cement kilns has had a special development of late years in the United States.

From the rotatory furnaces in the cement factories a coarse dust escapes and also a very fine dust rich in potash which easily flies through the blow pipe if special measures are not taken.

The potash volatilised in the ordinary conditions of cement manufacture varies between 25 and 95 % of the whole content of the ores employed. This depends not only on the process but on the nature of the material used.

The numerous processes followed to recover the potash from the cement dusts can be grouped into three: the electrostatic by moist or dry process, water pulverisation, and pulverisation in chambers of deposition.

Not all this potash is soluble in water, but as a rule about 90 % can be recovered by soaking in hot water for some hours, or more quickly under pressure. In this way the soluble potash obtainable in the United States will be from 60,000 to 65,000 tons per annum.

(1) The same method of precipitation of the dust by the action of electrostatic electricity, according to the COTTRELL or LODGE systems, is also recommended for the precipitation and collection of the dust which is produced during the crushing of nitrate of soda in the Chili factories (officinas). (Cf. F. G. DONNAN, *Report on a Programme of Investigation for the Chilean nitrate Industry*. Univ. Coll. London, 1921, p. 50).

An inquiry made by the United States "Bureau of Soils" has shown that the potash which escapes from the cement kilns of that country varies between 0.35 and 5.34 lbs. per barrel of cement, with an average of 1.9 lb. Allowing that 90 million barrels of cement are produced there annually the corresponding potash would represent about 86,000 tons, of which 80 %, or 70,000 tons a year, might be recovered. But up to date the largest quantity of potash recovered has been 1621 tons (1).

Electro-potash. — Residue obtained in the form of slag in the preparations of ferro-silicium, by treating in the electric furnace at 1800° C leptite or eurite, a common rock in Sweden, a gneiss rich in feldspar. As soon as the ferro-silicium has been separated from the slag containing it, the slag is finely ground and constitutes electro-potash. It contains about 11 % of potash, of which 10 % is soluble in hydrochloric acid at 20 % strength, in a water-bath, and 6-6.5 % in hydrochloric acid at 2 % strength, cold.

Electro-potash, compared with sulphate of potash in manuring tests, has given favourable results.

Ashes. — There are various kinds of these but the most suitable as potassic fertiliser are vegetable ashes both domestic and industrial. Their composition, and consequently their fertilising value, varies very much: those of ferns (28-29 % of K_2O), heath (16-17 %) and broom (30-31 %) are richest in potash; the following also yield good ashes:— the straw from oats, straw and husk of wheat, leguminous plants, buck wheat, poppy, rape — twigs of the olive tree (17.4 %) — grape residues — vine twigs — young elm leaves — bean pods — hops — hop cones — rushes — sedges — sea-weeds (6 to 15 % of K_6O), etc.

The fertilising action of ashes is mainly due to carbonate of potash, which predominates, but other potassic salts are present, such as sulphate, chloride, phosphate and silicate. They also contain a considerable quantity of carbonate of lime and in addition:— carbonate of magnesia — phosphates of lime and magnesia — silica — alumina — oxides of iron and manganese — etc.

A distinction should be made between *virgin ashes*, which are those hitherto referred to, and lixiviated ashes or *lyes*, which have lost almost all their potash but still contain phosphates and carbonate of lime. Lyes may consequently be used to supply the soil with these substances either by direct application or by incorporating them in composts and farm manure.

The ashes produced in largest quantities are wood ashes (2). Their composition varies according to the species of the wood burnt, as is shown by the following figures:—

(1) Cf. *Scientific American*, Feb. 1922, p. 107.

(2) According to the *Scientific American* (February 1922, p. 107), the potash from the ashes of wood refuse used as fuel and that of charcoal amounts to over 140,000 tons (of 907 kg.) a year, which corresponds to about 56 % of the quantity annually imported into that country.

	Potash	Phosphoric anhydride	Lime	Magnesia
Oak.	8 — 16 %	6 — 8 %	30 — 50 %	3 — 6 %
Beech	8 — 12	5 — 7	30 -- 50	3 — 6
Young elm	20 — 25	8 -- 10	20 — 40	8 — 10
Poplar.	10 — 15	10 — 13	30 — 50	8 — 10
Pine.	10 -- 15	3 — 4	30 — 50	3 — 5

The quantity of virgin ashes to be applied varies between 6 and 10 hl. per acre. Lye is applied in the proportion of 10 to 12 hl. per acre and is especially suitable for clay soils and peaty acid land.

The following information regarding the ashes of various vegetable residues may usefully be given :—

Ashes from almond husks. — A. De Dominicis has published at Portici (Italy) an interesting work on this subject dealing with the cultivation of the almond tree in Italy, which exceeds that of any other country, the average production being 156,400 m. tons of almonds a year, while Spain, which comes next in importance, only produces 99,300 m. tons.

Generally the green almond husks are fed to sheep, but, in recent years, they have also been burnt so as to use the potash in the ashes in the commercial preparation of concentrated lyes or by extracting the carbonate of potash from them. They have been used in this way specially in Sicily, where, as soon as the almonds are gathered, the husks are burnt on the spot in circular stone kilns.

The price of these ashes, which before the war did not exceed 8 to 12 *lire* per 100 kg. rose to 177 *lire* in 1916 and was still above 100 *lire* in 1920.

The virgin ashes from almond husks, dried at 105-110° C., contains : — potash 42.71 % — soda 2.73 % — phosphoric anhydride 3.15 % — lime 16.24 %. The dry husk gives from 7.35 to 12.64 % of ash, in which the potash may be as much as 56.75 %, according to analyses by the above-mentioned writer.

The husks representing, on the average, 40 % of the weight of the almonds, the 156,400 tons of almonds produced annually in Italy would yield 62,500 tons of husk which, at the rate ot 8.6 % of ash, would furnish 5,380 m. tons of ash containing 3,766 tons of carbonate of potash. Allowing the same percentage of potash for the Spanish almonds, the production in that country would furnish 2,391 m. tons of carbonate of potash which, added to the 3,766 tons in Italy, would make an annual total of 6,157 tons.

Orache (*Atriplex Halimus*) *ashes* (fig. 71). — This Chenopod of the coastal zones of the Mediterranean, South Africa and America gives ashes very rich in chloride of potassium (58-66 %); it has been recommended as a plant to be burnt for the use of its ashes as fertiliser.

Ash of tobacco stalks. — This has been utilised on a limited scale in the United States to obtain chloride of potash at a high standard. The stalks which contain about 20 % moisture were dried till they contained only 2 to 4 % and were then finely shredded. In this state they contain about 5 % of potash, and blended with a mixture of chemical fertilisers they act as a drying element and also add to the volume of the mass to be scattered.

Tobacco ash. — B. BURREL has recommended that they should be collected in places where many smokers meet, to make use of the potash.

In fact, this residue represents 30 % of the tobacco leaf smoked and contains 20 % of potash and 5-6 % of phosphoric anhydride. Allowing that 45,241 tons of tobacco were smoked in 1913-1914, this quantity represents 13,573 tons of ash containing 2715 tons of potash. This total quantity of potash is not very considerable and it cannot be collected. The very small quantity of ash which might actually be collected in meeting places could have no importance for the utilisation of potassic salts as fertiliser. Potash might also be obtained from tobacco refuse from the manufacture of smoking tobacco, that is to say from the stalks and other waste parts.

FIG. 71. — Orache.
From DR. A. FIORI, op. cit.

Potash from stalks and skins of bananas. — This subject has been investigated by M. R. H. ELLIS, who found in the rachis: moisture 91.6 % — dry matter 8.4 % — ash 2.4 % — potash 1.14 %. In the ash the potash reaches 45.9 %. One ton of stalks might yield 24 kg. of ash containing 45.7 % or 11 kg. of potash.

The skins of bananas contain, in a natural state :— moisture 88.2 % — dry matter 11.8 % — ash 1.77 % — potash 1.05 %. The ash contains 57.16 % of potash. The United States and the United Kingdom, leaving other countries out of account, import millions of bunches of bananas every year, which enables some idea to be formed of the large quantity of potash which might be derived from them by making thorough and complete use of them. Thus the 9 million bunches of bananas imported yearly into the United Kingdom yield : — *stalks* weighing altogether 16,328 tons, including 1372 tons of dry matter containig 13,7 % of potash, say 188 tons of potash — *fruit* (on the average 180 per bunch, yielding 6.8 kg. of skins) furnishing altogether 61,235 metric tons of skins containing 7226 tons of dry matter containing 9 % of potash, or 650 tons of potash.

Thus altogether 838 metric tons of potash would be obtained.

With regard to the needs of consumption, this quantity is not very great and moreover it is merely an estimate for it is impossible to collect and burn all refuse from the bananas consumed, most of the skins going into the dustbins where they are mixed with other refuse of all kinds.

Ash of sunflower stalks. — Potash extraction from this residue is of great importance in Russia, where in 1911 there were produced 12,001 metric tons (13,232 short tons).

From this ash there is obtained by lixivation potassium carbonate of varying standard from 78 to 90 %.

In Rhodesia also the same use has been made of sunflower stalks.

Ash of Artemisia *spp.* — These plants are rich in potash, the percentage in certain cases being 21.05 %.

They grow wild as is well known in many places. In the Western States various attempts have been made to utilise them, but apparently without commercial success so far.

Ash of water hyacinth (*Eichornia crassipes*). — This is a plant which in various parts of India tends to choke the canals. In the dry state it contains about 7.5 to 8 % of potash chloride, and 8.2 % of calcium phosphate, while in wood ash the potash is present largely as potassium carbonate (1). In the ash of this plant there is about 25 % of potash, but the quantity varies according to its growth and the nature of the soil. In 1917 it was reported that more than 170 tons of this ash, from 17,000 tons of green plants, were sold in Calcutta and Dacca.

Ash of ferns. — G. W. Robinson and E. J. Russell have found that the young plants give an ash containing about 50 % of potash, while the full grown plants contain a small quantity. The soil has some influence in this respect, in the sense that in a sandy soil ferns contain much less potash than on a clay soil. The season also makes a difference as the potash diminishes from May to October.

Potash from prickly-pears. — Approximately the same considerations apply as for bananas. Even in countries producing these fruits largely, as in Sicily, collection of the skins cannot be undertaken.

But in some countries, as in Queensland (Australia), certain kinds of *Opuntia* should be considered as regular pests which ought to be destroyed. It has been proposed to do this by means of trichloride of arsenic over 10,000 acres infested.

As soon as these plants are destroyed they might be burnt and their ashes, which could yield 15 % of potash, utilised. From 1 acre, 100 kg. of carbonate of potash of 80 % purity could be obtained.

Molasses. — When these have fermented they yield, besides alcohol, potash in the form of salt, which is obtained from the residue of their sediments. This salt contains mainly carbonates which are used as they are or are converted into sulphate of potash by treatng them with sulphuric acid. Molasses from beet contains, on the

(1) Cf. *Bull. Imp. Inst.*, London, 1921, No. 4.

average, 5 % of potash, plus 1.5 % of nitrogen, and it corresponds, in weight, to 4 % of the beet used.

Potash can equally be obtained from the residue of molasses sugar. This residue, due to one or another of the processes by which molasses are made, when concentrated at 35-40° Bé contains 9 to 10 % of potash, 50 to 60 % of organic matter.

By washing the salt obtained by calcination in closed retorts carbonate of soda and carbonate of potassium are obtained and also chloride of sodium potassium, while from the gases given off ammonia water and a lixiviation of sodium cyanide is obtained (1).

Ashes of wine lees. — The lees with ferments deposited at the bottom of the vats after the fermentation of the grapes form a soft mass which can be dried on filters; the solid residue can be reduced to ashes at a not too high temperature so as to avoid volatilization of part of the potash. From 100 kg. of dry lees, 17 kg. of ash very rich in potash are obtained on the average.

The lees deposited by wine in casks is very rich in tartar and should not be burnt but used for extracting cream of tartar and the manufacture of tartaric acid.

Ashes from prunings and trimmings of trees and shrubs. — Considerable quantities of potash can be obtained from these, especially from shrubs.

Russell experimenting with hedge clippings, at Rothamsted, found 9.6 to 13 % (average 10.9 %) of potash in their ashes. Hedge clippings furnish 15 lbs of ashes per 100 yards of hedge. Most certainly, says this writer, hedges should not be clipped solely to get ashes, but it is important to use for that purpose all ordinary clippings.

Russell also recommends the utilisation of the sweepings accumulated on the threshing floor which contain many seeds of weeds, for which reason they should be burnt. The ashes so obtained contain 11 % of potash corresponding to 5 lbs. of that alkali per acre of land under wheat. By using this residue as food for livestock and poultry,

(1) Cf.: 1) De Jussieu, Fabric. du Cyanure de Sodium par les vinasses de distill. ou de sucrat de mélasses in *L'Ind. Chim.*, No. 107. Paris, 1922, p. 530.

2) The *Scientific American* (February 1922, p. 107) relates that, in the United States, the total average quantity of potash contained in the annual crop of beet amounts to 20,000 tons (of 907 kg.). During manufacture part of this potash remains dissolved and part passes into the molasses, a good part of which is consumed by livestock who restore the potash in the dung. A portion of the potash is found in the residues of distillation and can be recovered by evaporation. The remainder of the molasses, about half, is used for extracting sugar from it, and the liquids of this process have potash in solution which is recovered by concentration. But it is doubtful whether these processes enable more than 4000 tons of potash a year to be obtained. According to H. S. Gale and W. B. Hicks, if all the potash from distillation molasses could be recovered, 30,000 tons of K^2O could be obtained. For the recovery of chemical products lost in the chimney of the kiln for burning the residues to obtain potash, the Effront process is used, which besides the potassic salt, gives, as residue of the principal work, sulphate of ammonia, cyanide of potassium, acetic acid and butyric acid.

3) For 20,000 t. of molasses Dr. G. Mezzadroli (*Giornale di Chimica Ind. ed Appl.*, Year III, No. 12, Milan, 1921, p. 565) indicates the following by-products :— sulphate of ammonia, 868 m. t., cyanide of potash, 104 m. t., acetic acid 1470 m. t., butyric acid 631 m. t.

as is generally done, there is a risk of introducing many seeds of weeds into the soil.

Peat and coal ashes. — In certain countries great quantities of peat is burnt either by direct combustion, or by distillation by tne MOND system, etc. In peat the ash varies between 10 and 16 % but it is very poor in potash and still more so in phosphoric acid ; it contains on the average :— carbonate of lime and quicklime 63 % — clay 7.5 % — silica 15 % — alumina 7 % — ferric oxide 7 % — carbonate of potash 0.5 %. It is therefore a calcareous fertiliser suitable for lime-demanding crops and for soils poor in lime. It is applied in the large quantities of 40 to 60 hl. per acre.

Coal ash contains less potash than wood ash does ; on the other hand, if fresh, it contains sulphides which may be injurious to crops but which are converted into sulphates if the ash is left for some time in the air before being applied.

The quantity of this ash produced in boiler furnaces is from 1 to 5 % of the weight of the coal used.

Being fairly rich in lime (15 %) and in sulphate of lime (4 %), it can be used as a calcareous fertiliser in quantities of 32 hl. to 40 hl. per acre, especially on compact, moist soils. It contains from 0.2 to 0.8 % of potash.

Chimney soot. — The soot from house chimneys and the flues of coal furnaces is a good potassic fertiliser, but as it contains empyreumatic products which may be injurious to crops, especially in a dry season, it should be used with care. It is used for top-dressing grass lands and also, turned into the soil, for wheat and clover, in the proportion of 25 to 30 hl. per ha., preferably in damp or rainy weather.

The following is an instance of the composition of soot :— moisture 12.50 % — carbon 3.85 % — ulmic acid 30.2 % — nitrogenous matter 20 % — acrid and bitter substances 0.5 % — various soluble salts, including acetate of ammonia, 10.84 % — insoluble salts 22.11 %. Wood soot contains, on the average, 1.15 % of nitrogen and coal soot 1.35 %. The composition of soot varies according to the nature of the fuels and also according to the system of combustion. According to WOLFF and VOLKER its average composition is as follows :—

	Wood soot	Coal soot
Moisture	5.0 %	4.0 to 10.0 %
Organic matter	72.0	45.0 » 70.0
Nitrogen	1.3	1.0 » 3.6
Phosphoric anhydride	0.4	0.3 » 0.4
Sulphuric »	0.3	1.7 » 8.7
Lime	10.0	4.0 » 5.0
Potash	2.4	0.5 » 2.7

Soot acts not only as fertiliser by the nitrogen, potash and phosphoric acid which it contains, but also as insectifuge by its bituminous and empyreumatic matter.

Soot, especially wood soot, also gives good results for the destruction of moss in lawns; it is applied in a very thin layer in spring or summer, when, after mowing, all the grass begins to grow again.

Potash of wool scour water. — The fat removed from sweaty wool by washing consists in wool-fat (lanoline), and in fat resulting from the combination of potash with certain fatty acids, and is soluble in water. This soluble matter varies considerably according to the breed of sheep, but as a rule is from 14 to 18 %, with 2-7 % of carbonate of potash, reckoned on the unscoured wool.

But the extraction of potash from wool is unremunerative if not done on a large scale and at the same time as the removal of fat. In Belgium, France and Germany the clearing of the wool is done by hot water on the so called counter current system, the water bearing the fat and brown in consequence is evaporated to drying point in Porion stoves and the pasty mass obtained is then calcined in reverberators or in gas retorts. In this second case the nitrogen is recovered as ammonia and cyanides and the combustible gas is used as such. The carbonaceous residue remaining in the retorts contains from 58 to 65 % of carbonate of potassium, and is broken up and washed with hot water: the clear liquid is evaporated up to the point of the crystallisation of chloride and carbonate of potash.

Formerly the solid fats of the wool were recovered from the scouring water by means of precipitation with sulphuric acid or bisulphate of soda, and the potash was lost in the liquid residue.

By the English Smith-Leach method the potash is recovered by means of concentration (to $^1/_{10}$) of the scouring water. The hot liquid is then subjected to centrifugation and three parts of matter obtained: 1) sand, 2) a potash soap solution, 3) wool fat. The soap solution is evaporated to drying point and then calcined to obtain carbonate of potash.

According to Winterbottom (1) it is possible to obtain from the whole of the wool washed in Australia 2812 long tons (of 1016 kg.) of potassium carbonate annually, but at present this quantity is lost as the scouring water is thrown away.

The following data, taken from researches by R. O. E. Davis, relate to some sources of production of potash from residues in the United States, and are considered of importance.

From cement factories 75,000 *short tons* (of 907 kg) of it can be obtained.

From blast-furnaces, from 50,000 to 200,000 *short tons*.

In 25 molasses distilleries the residues have supplied about 30,000 *short tons* of potash a year.

(1) Cf. *South Austr. Dept. Chem., Bull.* No. 2, 1916.

In sugar refineries more than 8000 *short tons* of potash a year can be obtained from the waste liquids. Of course these figures are theoretical: the quantities of potash hitherto obtained are much less. Thus, in 1918, 183 *short tons* of potash from cement dust and 632 *short tons* from waste liquids of refineries were obtained.

At the beginning of 1919, eighteen cement factories possessed the installation necessary for recovering potash.

Up to date little potash has been obtained from blast-furnaces.

The potash extracted from *seaweeds* has been dealt with in a special chapter (see p. 207).

From wool produced in 1914 in the United States (290 million pounds) and from imported wool (220 million pounds), it would have been possible to obtain 11,500 *short tons* of potash at the rate of 4.5 % of potash in the unwashed wool.

For the year 1916, from all sources, it may be estimated that there were extracted from industrial residues in the United States: — potash 40 %, phosphoric acid 8 %, and nitrogen 85 % of the total quantities used as fertiliser in that country (1).

The Chemical Bureau of the U. S. Ministry of Agriculture has recently undertaken experiments on a large scale with a view to a similar recovery of potash from wool scouring water (2). This water concentrated contains 14 % of potash, 1.25 % of nitrogen and 14 % of fats. The dry residue with the fat removed contained 24.5 % of soluble potash, 26.5 % of total nitrogen, and 0.6 % of fats. Mixing these residues with those of other industries a fertiliser is prepared containing: soluble potash 6.5 %, total nitrogen 6.1 %, of which 3.4 is soluble in water, fats 6.8 %.

(1) *a*) FR. BROWN's paper entitled "Importance of developing our Natural Resources of Potash" in *Yearbook of the Department of Agriculture*, Washington, 1916, p. 302, may be profitably consulted regarding the recovery of potash from residues in general and especially in the United States.

b) For the United States, there are the following statistical figures which relate to the pure potash extracted from various residues (in tons):—

	1920	1919	1918	1917	1916
Cement dust	1035	1051	1405	1471	0
Residues from molasses distillation	2951	2542	3145	2582	1674
Residues from sugar refining	3079	3282	1246	335	0
Wood ashes	181	325	611	563	374
Blast-furnace ashes	138	—	—	168	0

Cf. INTERN. INSTITUTE OF AGR. International Trade in Fertilisers, etc. Year 5, No. 3, 1921. For researches relating to *leucite*, see chapter Bisulphate of soda, p. 278.

c) For wool scouring water as a source of potash in the United States, see also: VEITCH, F. P. in the *Journal of Industrial and Engineering, Chemistry*. Vol. XIV, No. 5, Washington 1922.

(2) Cf. *Journal of Ind. and Engin. Chem.*, Vol. XIV. No. 5, Washington, 1922.

28. — Residues from gas-works.

Crude ammonia compounds — Formerly, " Laming's mixture " was in general use in gasworks for purifying the gas, that is to say for removing the sulphurous acid, cyanides, sulpho-cyanates, ammonia, etc. It was a mixture of sawdust (180 parts), lime (160 parts) and ferrous sulphate (30 parts) removed from time to time from the purifying chambers in order to restore its activity but finally thrown out when it became charged with sulphur and had lost its purifying power. It was then designated " crude ammonia compounds " and was fairly rich in ammoniacal and cyanic nitrogen. In a fresh state, it was considered poisonous for plants, but after about 2 months exposure to the air the compounds of cyanogen are converted into ammoniacal compounds. In any case, it is necessary to apply it a month and a half or two months before sowing or before growth starts. It is a good insectifuge.

In the present day large gasworks have almost entirely replaced " Laming's mixture " by the ash of iron pyrites (oxide of iron) from sulphuric acid furnaces, with which has been mixed a small amount of lime. This purifying matter retains the sulphur from the sulphurous acid and the compounds of cyanogen which have not been retained by the soda in special washers. The ammonia is also fixed by water in the gas washing apparatus. According as the oxide absorbs sulphur its purifying power decreases, but it becomes active again after a few days exposure in the air.

In these conditions the sulphide of iron decomposes and the sulphur resulting from this decomposition is deposited on the particles of oxide of iron (1).

This mass is used continuously for purifying until the proportion of sulphur in it reaches 45-50 %. It is then called " spent oxide of iron " or " exhausted purifying matter " and the sulphur is burnt out of it in sulphuric acid furnaces, or else extracted by ordinary solvents (sulphide or tetrachloride of carbon).

Large quantities of spent oxide of iron can only be utilised if the cost of transport is not too high and there is often an accumulation in gasworks of great heaps of unused spent oxide, nearly half of which is composed of sulphur. During the war, of course, this sulphur was entirely utilised, especially in countries poor in this element, but after the war as formerly, there was no profit in such use. A new use is that of the manufacture of " Supersolfo " which is dealt with in the next chapter.

Returning to crude ammonia compounds, it may be observed that their action in the soil is due :— 1) to ammoniacal nitrogen

(1) The regeneration is effected in accordance with the reaction : —

$$\underset{\text{Ferric sulphide}}{Fe_2S_3} + \underset{\text{Oxygen}}{O_3} + \underset{\text{Water}}{3\,H_2O} = \underset{\text{Ferric hydrate}}{2\,Fe(OH)_3} + \underset{\text{Sulphur}}{S_3}$$

(the nitrogen in sulphocyanates acts slowly and the ferrocyanides are unalterable); 2) to the considerable quantity of free sulphur (40-50 %), which acts as fertiliser; 3) to tar which is antiseptic; for this crude ammonia compounds, in large proportions, are injurious to plants, apart from the toxic action of the compounds of cyanogen.

Ammoniacal liquids. — These contain varying quantities of free ammonia and ammonia combined in the form of sulpho-hydrate, cyanide, carbonate. The total ammonia varies between 1.2 and 1.8 %.

In gas works where the ammoniacal liquids are not treated for obtaining sulphur, or chloride of ammonia, or pure ammonia, they are thrown away, although it would be advantageous to use the ammonia in them.

BONGIOVANNI has invented a process for the utilisation of these liquids which has been tested at the Rimini gas works (1): it consists in adding the ammoniacal liquid to superphosphate and evaporating it by means of furnace heat; as it evaporates further additions are made until effervescence is no longer produced. The residue is then dried in about 10 hours and the nitrogenous superphosphate obtained is pulverised. This product has been analysed as follows:— nitrogen 3 % — total phosphoric acid 15 %, of which 12,85 % is soluble in water and in citrate of ammonia. It is a phosphate of lime and ammonia following the formulae.

$$Ca(NH_4HPO_4)_2 \text{ or } Ca[(NH_4)_2PO_4)]_2$$

which is insoluble in water but decomposable by hydrolysis.

It is considered that this process, which is not new, is not likely to be commonly used for the following reasons: — 1) the necessity of transporting the superphosphate or the ammoniacal liquid; 2) the considerable expenditure of labour for all the manipulations; 3) the large consumption of fuel to evaporate the liquid which is ponred over the superphosphate; 4) the unfavourable conversion of mouocalcic phosphate (predominant) into bicalcic or reduced phosphate, insoluble in water, but soluble in citrate of ammonia.

Ammoniacal liquids and ammonia are obtained not only from gasworks but also from blast-furnaces, coke ovens, distillation of urine, and that of peat, from boraciferous " soffioni " (hot springs), from the manufacture of sugar by the osmotic process, etc. All these sources of ammonia were exploited during the war, but since the reopening of the market to the products of the synthesis of ammonia, obtained by the HABER, CLAUDE, and other methods (but mainly by the first, largely used in Germany), the manufacture of ammoniacal compounds with non-synthetic ammonia has experienced a great check, because the cost of production of these products is generally higher than that of the competing synthetic ammonia. This, as a matter of fact, is what has happened in the case of sulphate of ammonia, which several gasworks scarcely now find profitable to produce.

(1) BONGIOVANNI, C., " Utilizzazione delle acque ammoniacali del gas come concime " in *Le Stazioni Sperimentali agrarie italiane*, vol. LII, Nos. 10-11-12, p. 521. Modena, 1919.

They have therefore endeavoured to find some other profitable use for this important residue of the distillation of coal, but up to now without obtaining any positive results.

Among other by-products of illuminating gas, which during the war had to be collected and utilised along definite lines laid down by the several states, are tar, cyanides, sulphocyanates and benzene.

29. — " Supersolfo " (1).

Although the " Società Anglo-Romana per l' Illuminazione di Roma " (Anglo-Roman Company for lighting Rome) continued during the war to dispose of a good quantity of " spent purification substance " or " spent oxide of iron ", produced in its large S. Paolo Gas-Works, to a neighbouring sulphuric acid factory, it nevertheless possessed in 1919 an enormous amount of this residue. This continued to increase and consisted for about half its weight in elemental sulphur. Owing to the high price of commercial sulphur and the very low rate at which the spent oxide of iron could be sold, the Gas Company asked me to investigate the possibility of utilising the sulphur from the gas purification so as to get a reasonable profit.

In view of the great importance at the present time of fungicidal or insecticidal substances, I had resolved in the early years of the war, to investigate the preparation and use of the sulpho-calcic mixture or polysulphides of calcium, an insecticide and fungicide, largely used in the United States under the name of " lime sulphur " but little known and used in Italy or in other European countries. But I was convinced, as other experimentalists before me had been, that this remedy would never be generally used if it had to be prepared by farmers themselves, since as rule they neither could nor would effect the detailed operations required for its successful preparation ; consequently the polysulphides of calcium mixture must be systematically manufactured on an industrial scale so as to be placed on the market as highly concentrated as possible, as is done in the United States.

These considerations led me to suggest to the Anglo-Roman Company that the sulphur accumulated in the spent oxide of iron of the S. Paulo Gas-works should be converted into polysulphides of calcium, a mixture to be sold as insecticide and fungicide, useful against many plant pests and also against various parasites in the skins of domestic animals.

Thys proposal was favourably received and, shortly after, a preliminary mechanical installation was set going in the Gas-works,

(1) Cf.: 1) A. Bruttini, *Sulla Miscela solfo-calcica o di Polisolfuri di calcio come insetticida e fungicida*, Rome, 1920. — 2) Officina del gas a S. Paolo, Roma, *Alcuni risultati ottenuti col Supersolfo o Miscela superconcentrata di polisolfuri di calcio come rimedio insetticida e fungicida*, Rome, 1922. — 3) G. Trinchieri, *Per un preparato anticrittogamico e insetticida meritevole di maggiore considerazione*, Florence, Italian Colonial Agricultural Institute, 1921. Publications 1 and 3 contain a copious bibliography on this subject.

while another completely independent and more powerful installation was prepared (Fig. 72 and 73) close by.

This was the beginning of the first industrial manufacture of polysulphides of calcium, towards the end of 1919, following the lines of my patented process for utilising the sulphur derived from the purification of illuminating gas.

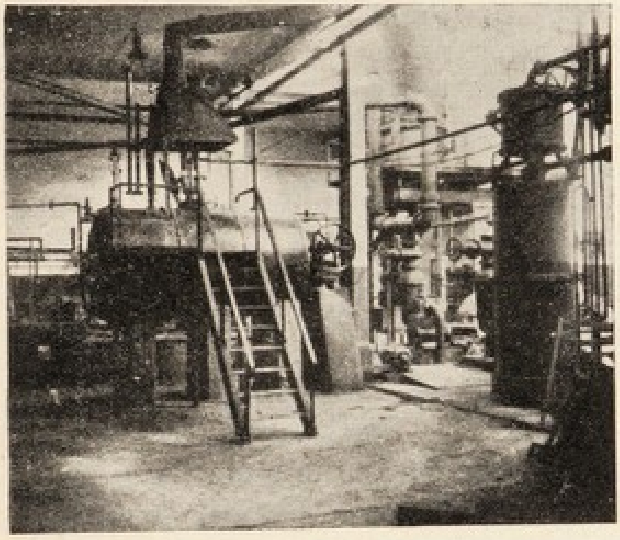


Fig. 72. — Manufacture of Lime-sulphur in "San Paolo Gas-works, Rome".

Reaction Boiler (on the left).

The manufacture of polysulphides of calcium from commercial sulphur dates back a number of years, and they appear to have been used by Hendrick as fungicides since 1833; then, since 1852, they were used in Australia in the preparation of sheep dips. In 1880, they were first used, in California, on fruit trees, but Prof. Peyron of Turin had previously in 1854 recommended their use against vine mildew.

This remedy soon became used widely, especially against *Aspidiotus perniciosus* in America and *Chrysomphalus dictyospermi* in Italy and elsewhere, but it was always prepared by boiling, in a boiler, a mixture of about 10 parts of quicklime, 20 parts of powdered commercial sulphur and 100 parts of water (Savastano's formula). Boiling had to continue for 45 to 60 minutes and the operation had to be conducted with special care. The product obtained is a mixture containing mainly tetra- and penta-sulphide of calcium, in density between 22 and 24° Baumé, that is to say too low to allow of transport to a distance. This process was therefore only of use for domestic manufacture.

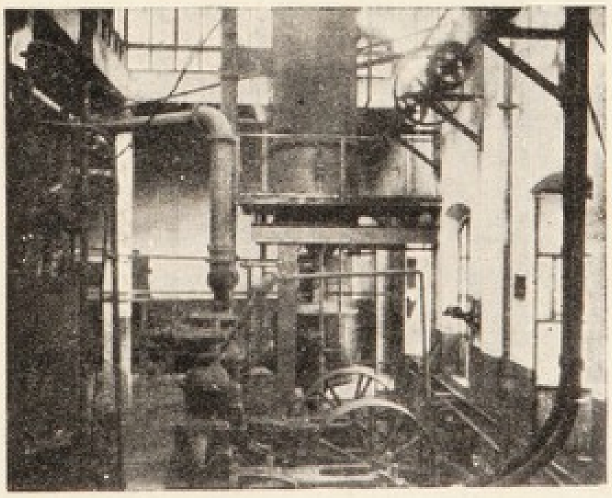


Fig. 73. — Manufacture of Lime-sulphur in "San Paolo Gas-works, Rome".

Vacuum-evaporator.

The novelty in the manufacture which I established at the Gasworks in Rome consists in the use of sulphur from the spent oxide of iron, never before so used, and in the concentration of the mixture under reduced pressure up to 37-40° Baumé. A super-concentrated mixture of polysulphides of calcium was thus obtained which is sold under the name of "Supersolfo". As has already been said, this product is an aqueous solution of various sulphides of calcium which, theoretically, may be five, that is to say comprised between CaS and CaS_5 but in practice, if the manufacture is really successful, the tetra- and pentasulphides (CaS_4 and CaS_5) predominate in it, and to this fact is due the effect which it has on parasites.

The concentrated solution of these two polysulphides, if undisturbed and kept from contact with the air, does not undergo any perceptible changes and keeps well for a long time.

The action of "Supersolfo" on plants is not only insecticidal and fungicidal, but also active, by reason of the effect, now well known, which very finely divided sulphur has when deposited on the plants treated. To this active action of ordinary polysulphides is added, in the case of "Supersolfo", that of the iron which it contains in small quantities in a perfectly soluble condition. This property renders "Supersolfo" capable of exerting a double active action of plants, which makes it very beneficial not only in controlling insects and fungi, as has previously been mentioned, but also for spraying on healthy plants with the object of making them stronger and more resistant to the attacks of their numerous enemies.

The density of "Supersolfo", as has been previously noted, is between 37 and 40° B, while that of the sulpho-calcic mixture made in the United States ("lime-sulphur") does not exceed 33-35° B. For applying to plants, "Supersolfo" should be suitably diluted with water: thus for spring-summer use, 2 % solutions of it are made; for winter use, the strength is doubled or trebled. In these solutions concentrated extract of tobacco, arseniate of lead, soap, creolin may be mixed, but not copper salts, nor Bordeaux mixture, because these substances precipitate the copper. Nevertheless I have succeeded in preparing a "Supersolfo ramato" (cupric "Supersolfo") containing perceptible quantities of copper in perfect solution at any state of dilution and I have also been able to get a "Supersolfo" containing mercury in solution.

When it is only intended to make a few sprayings with "Supersolfo", the copper sprayers used for Bordeaux mixture can be used, but for constant use galvanised iron or lead-lined or else brass or aluminium sprayers should be used.

The insecticidal and fungicidal property of "Supersolfo" is explained in several ways, but it may be admitted that its action is due both to the finely divided sulphur which is deposited on the plants and to the sulphuretted hydrogen which polysulphides give off under the action of the carbonic acid gas in the air.

Although "Supersolfo" cannot be considered as an universal remedy (no such remedy exists), it lends itself to the simultaneous and effective control of most annual and vegetable parasites, among which may be mentioned: 1) Acaridae — Aphides or plant-lice — Pyrales — Cochylis — Tineidae — Worms — Coccidae (*Chrysomphalus*, *Mytilaspis*, *Aspidiotus*, *Lecanium*, *Diaspis*, etc.) — Apple Hyponomeute — Apple Pyralis — Rose green-fly — etc.

2) Bacterial disease of the apple — Brown-rust of the peach — Spot-disease of the pear — Smuts in general — Mildew of the peach, currant, etc. — Brown rot in fruit — *Cycloconium oleaginum* of the olive — Vine mildew etc. — *Clasterosporium carpophilum* — Lattice-rust of the pear — Mosses and Lichens — Chlorosis — etc. etc.

" Supersolfo " is also of proved efficacy against mildews especially that of the vine, for which it replaces sulphur powder, and is decidedly more economical and stronger in effect. It has been repeatedly tried with positive results against vine peronospora.

" Supersolfo " is also a certain remedy against several parasites of the skins of domestic animals (scab or mange, ticks, lice, eczemas, etc.), for which it is applied by means of dips (3 to 5 litres of " Supersolfo " per 100 litres of water, with the addition of creolin in the proportion of 5 per 100 of " Supersolfo ").

Method of use. — It clings to the leaves well and makes a clean mark. It is advisable to give at least one *winter dressing* to fruit-trees and vines, even if there are no traces of disease. In this way the plants are saved from many diseases which might develop in the spring.

Two or three *spring-summer dressings* should follow. As a rule the number of the dressings is determined by the presence of the parasite: if it continues to make its appearance the treatment ought to be repeated.

Doses — For the spring-summer treatment these will be:

Water	100 litres.
" Supersolfo "	2 litres.

There are plants whose leaves can well stand larger doses, which are therefore advisable — when possible — in the event of severe attacks.

For winter dressings at least double the amount of " Supersolfo ". For baths to animals: from 3 to 5 per cent.

Preservation. — " Supersolfo " if in sealed receptables keeps a long time. Receptacles left half full must be well corked. It is advisable to mix with water at the time of using. Pure water should be used if possible.

30. — Ammonium-potassium sulpho-cyanate.

The firm Alphonse Dupont & Cie of Haren-lez-Bruxelles (Belgium) manufactured, before the war, a nitrogenous potassium fertiliser called Ammonium-potassium sulpho-cyanate. For this product crude ammoniac, or other allied substances (furnishing sulpho-cyanates) and residues from the manufacture of beet sugar (furnishing potash), were used.

Owing to its nature this fertiliser was little known and, as far as I know, no one had tried it in Italy before I did (1). It is generally

(1) Cf. A. Bruttini, " Sulla produzione di nuovi concimi azotati e sull'impiego del Solfocianuro ammonico-potassico ". *Bollettino della Società degli Agricoltori Italiani*, Year IX, pp. 20-21. Rome, 1904.

admitted that cyanogen compounds are poisonous for plants, even in small doses, so much so that formerly much importance was attributed to the quantity of sulpho-cyanates found in the sulphate of ammonia. But the facts have proved that these fears were exaggerated.

The fertiliser which I tested was a fine dry black powder containing 4.5 to 5 % of nitrogen and about as much potash, plus 0.5 % of naphthalene. The nitrogen was found for the most part in the form of sulpho-cyanate and in a small degree in the ammoniacal or nitric forms. Spread on the ground this fertiliser rapidly oxidises (see Cyanamide of calcium) being converted into carbonate of ammonia, then into nitrate on the one hand; into sulphur, then into sulphate of potash, on the other hand.

I ascertained that these reactions are proportionally more rapid when the soil is friable and carbonate of lime is present.

The action of this product is both fertilising and insectifugal. Several trials of it have been made in Belgium, with good results, on sugar-beet, cereals, etc.; it is applied 3 or 4 weeks before sowing. I have tried it on various crops, applying it both before and during their growth and I have been able to conclude that during growth it is injurious to gourds but in no way to wheat, which shows a peculiar resistance to the action of sulpho-cyanates.

Owing to the rapid conversion of the nitrogen of the ammonium-potassium sulpho-cyanate into ammoniacal nitrogen, its use in manuring should be mainly determined by the cost of the nitrogen and potash which it contains.

31. — Explosives left over after the war.

The very large quantities of these explosives, in all belligerent States, gave rise to numerous proposals for utilising such as could not be kept. Destroying them was the simplest means of getting rid of them: this was effected easily enough by throwing them into the sea, a lake or a river but, besides fouling the water, the latent mechanical force and the chemical action which certain compounds in these explosives could exert in the soil would thus be entirely lost.

Among the many suggestions made, two attracted most attention and have been most widely applied on a large scale: — the use of explosives in agriculture, especially for clearing and breaking up land; the utilisation of the nitrate of ammonia as fertiliser.

The former use cannot be dealt with here (1); on the other hand the latter, applied by the method invented by Prof. F. Garelli and M. Angeletti of Turin (2), will be briefly described.

(1) Cf. A. Bruttini, "Sull'uso degli esplosivi in agricoltura" in *L'Agricoltura italiana illustrata*, Year I, Nos. 4 and 6. Milan, 1919.

(2) Cf. F. Garelli and A. Angeletti, "Preparazione di concimi azotati-potassici mediante gli esplosivi a base di nitrato ammonico" in *Giornale di Chimica industriale e applicata*, Year III, No. 9. Milan, 1921.

This method consists in preparing mechanical mixtures of the explosive with inert matter such as sand, earth, pulverised leucite peat; these mixtures have been generally well received by farmers.

The foreign constituents which are found in same explosives (binitronaphthalene, nitrotoluene, various organic matters) are in relatively small quantities and consequently not injurious.

But when these constituents have to be separated their quantity makes it necessary to use water which readily dissolves the nitrate of ammonia so that concentrated solutions of it are obtained. Instead of evaporating these solutions at great expense, they are mixed with peat dust and a nitro-ammoniacal fertiliser is obtained rich in humus, neutral, porous, which keeps well when the moisture does not exceed 25 %. In these conditions, it is inert, easily transported and spread.

100 parts of peat with 15 % of moisture readily absorb 150 parts by weight of solution of the explosive containing 80 % by volume of nitrate of ammonia, and 250 parts by weight of fertiliser containing 28 % of moisture and 13 % of nitrogen are thus obtained. If it is exposed to the air and stirred the moisture in it can be reduced to 20 % which increases the nitro-ammoniac proportion to 14-15 %.

Another method of utilisation for which the writers already quoted are responsible consists in adding to the concentrated solution of nitrate of ammonia salts such as chloride or sulphate of potassium and chloride of sodium. The most suitable mixture appears to be that with chloride of potassium: to 100 litres of 80 % solution of nitrate of ammonia 78 to 80 kg. of commercial chloride of potassium is added and heated to boiling point to obtain complete solution. This is stirred and allowed to cool, then filtered by suction to separate the mother liquid, or the crystals merely allowed to drain. About 150 kg. of double salt nitro-ammonium-potassium chloride and 35 kg of mother liquid containing 8 to 10 % of total nitrogen are thus obtained. This salt contains: total nitrogen 16.82 % (including 8.41 % of nitric nitrogen and 8.41 % of ammoniacal nitrogen) — potash 31.15 % — chlorine 23.11 % — moisture 1.60 %. Of the nitrogen contained in the solution of the explosive, 90 % is found in the mixed crystallised salt. What passes into the mother liquid can be easily utilised by absorption by means of peat dust (35 parts of mother liquid + 25 parts of peat).

A *nitro-ammonium-potassic peat* is thus obtained containing 18 % of moisture, 4.6 to 4.7 % of total nitrogen and 18 % of chloride of potassium.

To sum up, from 100 litres of solution of the explosive (density = 1.30), 150 kg of nitro-ammonium-potassic salt and 45 kg. of nitro-ammonium-potassic peat are obtained. This double nitrogenous-potassic salt forms a concentrated non-hygroscopic fertiliser, easily kept and transported, capable of being mixed with earth or other inert substances and easy to apply. The binitronaphthalene which passes partly into the solution of the explosive gives this salt a yellowish colour helping to characterise it.

32. — Sodium bisulphate and Soda residues.

This is a by-product of the manufacture of sulphuric acid by the use of lead chambers, for which there is required a current of various oxygenated compounds of nitrogen, which oxidise the sulphurous acid into sulphuric acid. These nitrous compounds are obtained by treating nitrate of soda with sulphuric acid, and bisulphate of soda remains as residue.

This salt has had many uses owing to its acid reaction. Among other uses, it has been recommended to mix it in the proportion of 2 to 1 with leather parings and to heat the whole to 300° C., an operation during which the nitrogen in the leather is in a large degree converted into sulphate of ammonia; the product is mixed with mineral superphosphate and used as fertiliser and also as a weed killer.

During the war, as there were large quantities of bisulphate of soda available in Germany, it was used for making double sulphate of soda and ammonia (containing 9 to 10 % of nitrogen) by saturating it with ammonia. It is said that this fertiliser gave good results. It was, moreover, known that a mixture of sulphate of ammonia and chloride of sodium had given in previous experiments a higher surplus yield than sulphate of ammonia used by itself, which proved that soda might partly replace potash in manuring (1).

Bisulphate of soda is used in industry as a powerful flux. Before the war the utilisation of the potash in *leucite* and *phonolite* had been discontinued from practical and economic considerations, but it was revived in many places during the war and bisulphate of soda was used in several patented processes conjointly with other fluxes and reducing agents.

All this fresh research was expected to lead to the solution of the problem of the supply of potash salts in various countries, and among others in Italy; but the result was the same as that of pre-war research, namely laboratory and field experiments showed that the molecular structure of these double silicates of alumina and potash is so resistant that fluxes, reducing agents and high temperatures do not achieve the practical result of rendering the potash soluble in water, as are the ordinary potassic salts of Stassfurt and Alsace.

The leucite and phonolite problem is thus once mor shelved leaving a clear field to trade in these potassic salts.

It is to this conclusion that I have been led by personal experience during a long series of researches (still unpublished) in the laboratory and in the factory, made during the war with leucite at the S. Paolo Gas-works (Rome), with various processes for attacking leucite in furnaces of a new kind; I always obtained partial results, as indeed. all other experimentalists have done.

(1) Cf. Dr. H. Grossmann, R. Rueb, W. v. Flügge, *Beiträge zur Kriegswirtschaft* "Düngemittel im Kriege". Berlin, 1917.

Lately Professor E. PATERNÒ has supplied information (1) as to his process patented in 1919, consisting in the extraction of potash from leucite and from other silicates of potassium by means of treatment of the silicate in a powder with a solution of sodium chloride or other alkaline-earthy or mineral-chlorides. This is done in an autoclave under certain conditions of pressure, temperature and time. The author states that in this way 90 % of the potash of the leucite passes into solution.

There are other similar patents, but the economic advantage as compared with that of the ordinary mineral salts of potash is still to be determined.

The soda residues are of variable composition : they contain principally sulphur of lime (CaS), quick lime, calcium carbonate, aluminate and silicate of soda, and carbon. They are chiefly used to recover the sulphur by various processes, but there is also the LOMBARD process (2), by which use is made of them to obtain precipitated phosphate (dicalcium phosphate). These residues treated with sulphuretted hydrogen give a sulphydrate of lime which if brought into contact with a monocalcium phosphate precipitates dicalcium phosphate.

33. — Residual Lime from acetylene, etc.

This is the calcium hydrate remaining as residue of the treatment of calcium carbide with water for the purpose of disengaging acetylene, according to the well-known reaction :

$$\underset{\text{Calcium Carbide}}{CaC_2} + \underset{\text{Water}}{2\,H_2O} = \underset{\text{Acetylene}}{C_2H_2} + \underset{\text{Hydrate of calcium.}}{Ca(OH)_2}$$

This lime can be used as a fertiliser once it is dried and reduced to a powder in the air. It is also of use to whitewash and disinfect hen yards (3).

34. — Basic Slag.

This is mentioned here merely to recall it, since though strictly a residue of the steel industry, its long established importance places it among chemical fertilisers produced on a large scale.

For an account of this therefore the reader is referred to works dealing with chemical fertilisers.

(1) Cf. *Giorn. di Chim. Ind. e Appl.*, Year 5, No. 1, Milan, 1923.

(2) P. BAUD, Chimie industrielle, Masson et Cie. Paris, 1922, p. 71.

(3) The lime may be supplied to the soil by other residues, as : Ground lime, Gas lime, Lime Mud, etc. Cf. D. A. GILCHRIST, Lime and its uses in Agriculture. *Agric. Dep. Armstrong College, Newcastle-on-Tyne. College Bulletin* No. 12, 1923.

35. — Soap work residues (1).

A distinction must be made between soaps made with soda and those made with potash. In the former case the residues have a poor fertilising value ; in the second, on the other hand, their value is much higher.

Residues consist in a mixture of : lime, lime combined with soda or potash, sulphate of lime and soda, lye ashes from the lixivated ash, sodium chloride and calcium chloride. These two last substances are the result of the separation of the soap from its saturated solution with sea salt.

It is obvious from these components that this residue cannot be spread directly as a fertiliser and must be employed in limited quantities, and mixed with composts, where it should remain long enough to lose its caustic quality, very injurious to plants.

This residue does not repay more than trifling costs of transport and is not usually in demand.

36. — Residues from minerals containing radium (2).

After the radio-active material has been extracted there remains in the special minerals treated a very small quantity which communicates to the residues a slight radio-activity but one that is efficacious with plants. These residues, reduced to a fine powder, are mixed with stimulating chemical fertilisers. It should be noted however that the action of these residues is not uniform. It appears that radio-activity encourages nitrification.

The average quantity of radio-active stimulant to be applied per acre is 20 kg.

37. — Fertilisation by means of carbon dioxide.

This is a question mooted some years ago and still much debated. The opinion of many is in favour of this kind of manuring, but there are also many contrary opinions. It is for this reason that an explanation of the matter seems in place in this work (3).

(1) Cf. J. Fritsch, op. cit.

(2) L. Fournier, Les stimulants radio-actifs en Agriculture. Leur rôle dans les engrais. Libr. de l'Inst. Nat. Agr. Paris, s. d.

(3) A detailed analysis of this subject, based on various enquiries was published in the *Internat. Review of the Science and Practice of Agriculture* (International Institute of Agriculture) July 1921, No. 704, and January 1922, No. 19. It will be worth while to consult this for more detailed information on the subject and for the bibliography. See also : *Annuario Scientifico e Industriale*, Year 57, 1920, v. 2, p. 137. Milan, Fratelli Treves, 1921. Among the experiments made in Germany with this waste from the blast furnaces the principal were those of the founderies of Hugo Stinnes and the Deutsch Luxemburg Co. at Horst. (Cf. *The Chem. Trade Journal and Chem. Eng.*, v. LXX, No. 1814, 1922, p. 243).

The carbon dioxide of the soil is of great importance to the plants (BORNEMANN) and it is in direct relation to the bacterial activity to which the repeated ploughings and additions of organic matter largely contribute.

For the application to the soil of the carbon dioxide escaping, as refuse gas, from generating furnaces, blast furnaces, etc., there as been adopted in Germany a special system of metal tubing made of pipes pierced with holes, placed in the ground and fastened to a large pipe into which the carbon dioxide is forced by fans. Experimenting with wheat, oats and other plants, BORNEMANN observed that in all cases there was a perceptible increase of yield. FISCHER experimented in 1919 in carbonication of poor land, with fennel, soya, beetroot, lupins, haricots, tomatoes, etc. and obtained satisfactory results. He observed a better result was obtained from the action of the carbon dioxide when the land is well manured with all the nutritive matters possible. This use of non-biological carbon dioxide is only possible in the neighbourhood of factories. For the generality of lands the carbon dioxide employed has to be obtained by decomposition of the organic matter supplied to the soil. CLAASSEN, without denying the valuable action of non-biological carbon dioxide, does not believe in the practical possibility of its application and does not feel that the method can be one of economic value, while the employment of organic fertilisers to bring about "automatic carbonic manuring" is alvays advantageous.

REINAU and BORNEMANN, replying to CLAASSEN'S observations, while in no way undervaluing the use of biological carbon dioxide, admit that the employment of non-biological carbon dioxide might be encouraged by State subsidies for installations and that if not suitable for field cultivation, it is so for kitchen gardens and other gardening.

REINAU is equally in favour of the use of non-biological carbon dioxide, but RIPPEL, who does not share his opinion, says that the increases of yield have been obtained by an extension of the use of fertiliser and by irrigation. It is fantastic according to him to believe that by augmenting the percentage of carbon dioxide in the soil atmosphere from 0.0300 to 0.0302 %, a 20 % increase of yield could be obtained.

RIEDEL however is strongly of opinion that an installation of tubing does not present any special difficulties and the distribution of gas and its concentration can be regulated at any hour of the day. In the neighbourhood of blast furnaces thousands of acres can thus be gassed. The branch pipings laid 25 m. apart and 100 m. long only require about 180 m. per acre (100 m. per *morgen*) of piping. The power required to force the gas through the pipes is moderate if provided by a fan. Further in conclusion RIEDEL agrees that organic manuring is always advisable, but that there is no need to rule out the mechanical kind, as appreciable results will have been obtained if only a few hundred thousand acres in Germany are treated with gas.

Blast-furnace gases can also be utilised after they have served as motor power in the gas motors, from which they can be delivered, like the waste gas, into the tubing installed on the land. Even if they contained carbon monoxide in consequence of incomplete combustion, this gas would not be injurious to the plants.

He adds that gassing should and may be employed everywhere where conditions are favourable to further development of the process.

According to D. RIEDEL the quantity of carbon dioxide given off per day by blast-furnaces producing 1000 tons of cast-iron and consuming 1100 tons of coke, if completely absorbed and assimilated by potatoes, would produce 4000 tons of tubers.

38. — Human Excreta. "Flemish Manure", Engrais Flamand.

Human excreta have been used from time immemorial as fertilisers and are still so used in many countries, and in some, as will be seen, they are of special importance even ranking above every other kind of manure.

An adult human being produces daily about 2.75 lbs. of excreta, of which 2.4 lbs is in the form of urine and 0,33 lbs. of faeces. In estimating the total amount of excreta produced by a population, difference of age, type of feeding, work and the inevitable losses during excretion, collection and preservation must all be taken into account. Persons who live well and consume much meat and are not engaged in continuous and arduous work eject matter which is richer in fertilising substances than that produced by persons less substantially fed and working under more onerous conditions. Children and young persons assimilate from their food more nitrogen, potash and phosphoric acid than is the case with adults.

MÜNTZ and GIRARD as the result of a long series of experiments have ascertained that the average daily amount excreted per individual are as follows.

	Faeces gm.	Urine gm.
Quantity (natural condition) . .	133.00	1200.00
» (dried)	30.30	64.00
Nitrogen	2.10	12.10
Phosphoric anhydride	1.64	1.80
Potash	0.73	2.22

The figures show that urine is richer than faeces, especially in nitrogen and potash.

The composition of the excreta is very complex. The faeces contain small quantities of albuminoids and fatty matter, partly saponified, biliary substances, lecitin, fatty acids, taurine, indol, scatol, phenol, certain soluble salts and phosphates. According to

BERZÉLIUS the faeces have an average of 75 % of water, 21.72 % of organic substances, of which 2 % is nitrogen, mineral substances 3.28-3.75 %. Urine contains urea, uric acid, hippuric acid, mineral

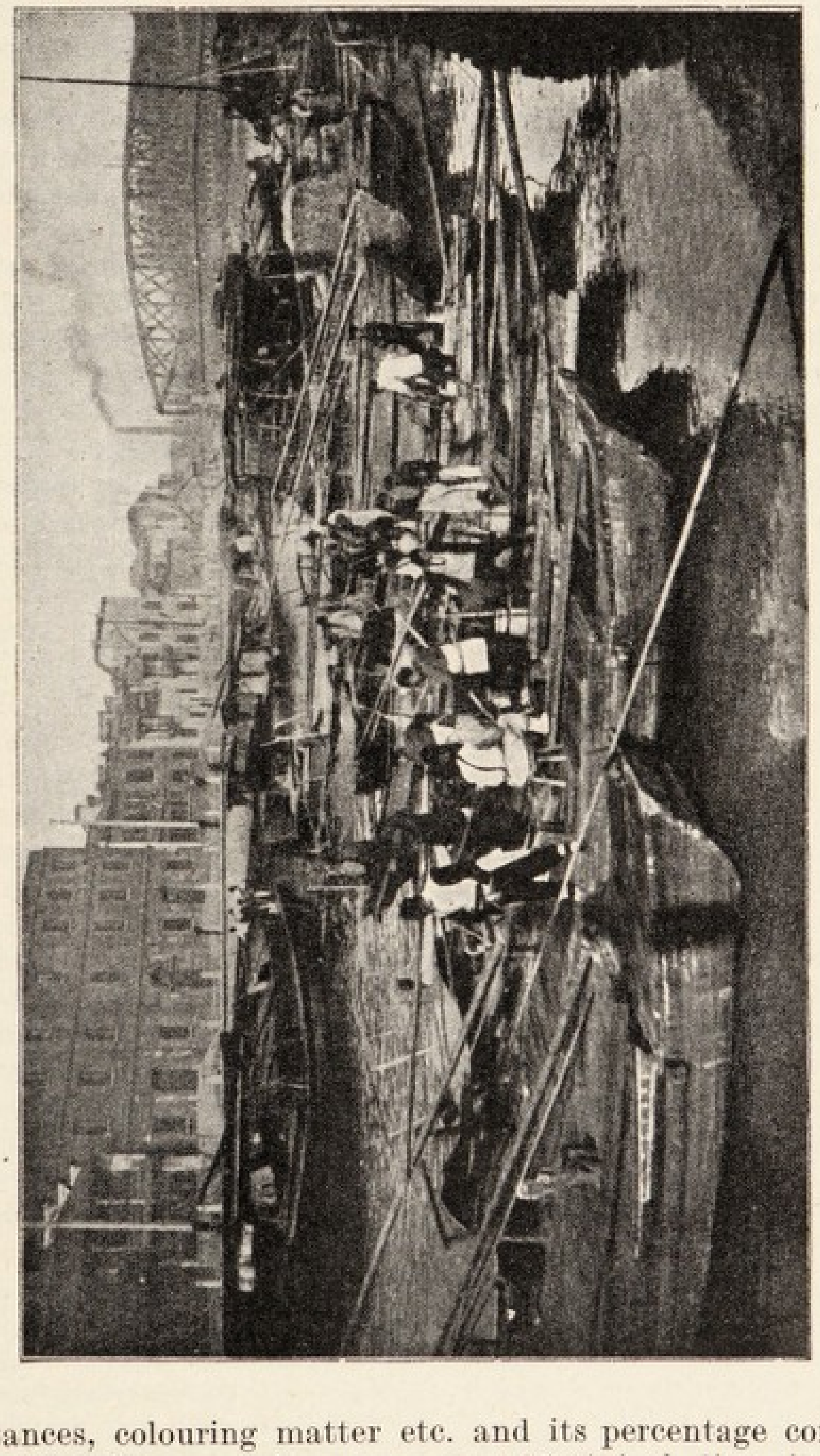


Fig. 74. — Flotilla of boats for the collection and transport to the country of human excreta at Shanghai (China).

Reproduced from the work of F. H. KING already quoted (s. p. 284, p. 195).

substances, colouring matter etc. and its percentage composition is: water 93.30 %, organic substances 4.85 % including nitrogen 1.42 %, mineral substances 1.84 %.

The manure which comes from the mixture of faces and urine in privies is known as "Flemish manure" (Engrais flamand) because of its long use in Flanders ; it is however also commonly employed in other countries, such as Alsace, Allemagne, etc., Provence and le Dauphiné. In Italy it is chiefly used in the central area, especially in Tuscany, its application being most intense in the district of Lucca and the plain of Pisa where, as in Flanders, the farms are provided with a cistern in stoneware in which the sludge brought in special barrels from the centres of population is stored.

But the most remarkable and characteristic instance of the use of human excrements as manure has been provided from time immemorial by China and also by Corea and Japan (1). The following details are of interest (2).

For a population of 400 millions, reckoning the annual amount of excreta produced per individual in liquid and solid form at 1074 lbs, the total annual production would amount to 194,800,000 metric tons of wich it is estimated that $^2/_3$, *i. e.* 129,800,000 are used for fertilising purposes.

Assuming that on analysis this manure contains 1.63 % nitrogen,0.20 % phosphoric acid and 0.24 % potash the following are the amounts and values obtained each year, reckoning the unit of nitrogen as worth 44 cents, the unit of phosphoric anhydride 22 cents and the unit of potash 27 cents:—

	Millions of lbs.	Millions of kg.	Millions of dollars
Nitrogen	1799	816	360
Phosphoric anhydride.	569	258	57
Potash	683	310	85
Totals. . . .	3051	1384	502

These totals show how impossible it would be to attempt to substitute chemical fertilisers for the manure produced by human beings.

The greater part of the manure produced is not however put on the market but used on the spot. The value of that actually bought or sold may be estimated at about 50 million Chinese or 30 million American dollars (3).

(1) Cf. F. H. King, Farmers of forty centuries or permanent agriculture in China, Korea and Japan. Madison, Wis., 1911, p. 193.

(2) Cf. *The American Fertilizer*, v. LIV, No. 10. Philadelphia, 1921.

(3) In connection with the use of "Flemish manure" in China, the following passage taken from an 18th. century book, which bears out the methods of use shown in the illustration, seems to be of interest. "The workers are chiefly concerned with rice-cultivation ; they carry the manuring of the soil to great lengths and for this purpose collect every kind of ordure with minute care, including the excreta of human beings, dogs, pigs and other animals which they exchange for wood, grass or linseed oil. This kind of manure which elsewhere would be likely to damage the crops is extremely valuable for Chinese soils and the Chinese also knows how to dilute it with water before use. The manure is collected in baskets which are generally covered and carried on the shoulders and the whole process makes for the cleanliness of the towns from which the excrements are carried away daily". (Cf. J. B. du Halde, Description géographique etc., de l'Empire de la Chine et de la Tartarie Chinoise, v. II. Paris, P. G. Lemercier, MDCCXXXV, p. 64).

A large part of the manure known as Chinese *taffo* is in the form of dry bricks, consisting of human excrements mixed with clay. This method of preparation known as the earth system has the advantage of making the sludge inodorous within a short time and of facilitating drying when the contents of special tanks, in which human excreta are collected and from time to time covered with clay, are exposed to the air (1).

According to figures given by WOLFF, KELLNER and CARPENTER, the population of the United States and Europe pour annually into the sea, the rivers and subterranean waters, from 2626 to 5436 metric tons of nitrogen, 853 to 1880 tons of potash and 352 to 1385 tons of phosphorus for each million of the adult population.

In the Far East according to G. H. KING (2) for more than 30 centuries these enormous quantities of refuse matter have been religiously utilised. To-day 400 million adults are employing in agriculture 150,000 tons of phosphorus, 376,000 tons of potash and 1,158,000 tons of nitrogen, supplied by the total mass of over 182 millions of tons of excreta, collected from house to house in town and country and sold to the farmers. (See figs. 74, 75, 76).

As absorbents for human excrements ashes can also be used with the addition of sulphuric acid and coal dust and then air dried (ROCHDALLE system) or the residues from wool factories, chopped straw, etc. (System GOUX).

Peat is also an excellent absorbent when used dried and powdered in the proportions of $^1/_5$ to $^1/_4$ of the crude manure. Dry sawdust and tan refuse have a similar but less marked action.

The following system of collecting human excreta is frequently used on farms in Tuscany. A manure pit is constructed of masonry with an adjoining cesspit over which is built the farmer's family latrine and with which are collected, in addition to the solid and liquid excreta of the family, the sludge liquid from the dungheap and the stable urine. When the dungheap requires moistening the liquid from the cesspit is poured over it by means of the sludge pump and when the manure is actually being used it is mixed with the contents of the cesspit or sometimes these are used separately for crops at different stages of the growth process, as for example for maize at the time of earthing up, etc.

If this method were generally followed in country districts, the problem of the collection and improved utilisation of human ordures would be solved, but the system is clearly applicable only to countries where agriculture has reached an advanced stage and where the capital available for each farm is sufficient to provide the dung pit of masonry and its accessories. Even however in countries where agriculture may be regarded as advanced, the manure produced by

(1) In 1908 (Cf. F. H. KING, op. cit., p. 194) the town of Shanghai entered into a contract with a Chinaman, allowing him in return for a payment of 31,000 gold dollars the right to collect 78,000 tons of human excrement for sale to farmers. For the transport of the manure, fleets of boats are employed the whole year round.

(2) Op. cit., p. 194.

human beings continues to be lost in many districts and thus an important source of wealth is dissipated.

The "water" and "everything to the drains" systems are the cause of vast losses of fertilising substances ostensibly necessary on hygienic grounds. The "water" system is generally governed by

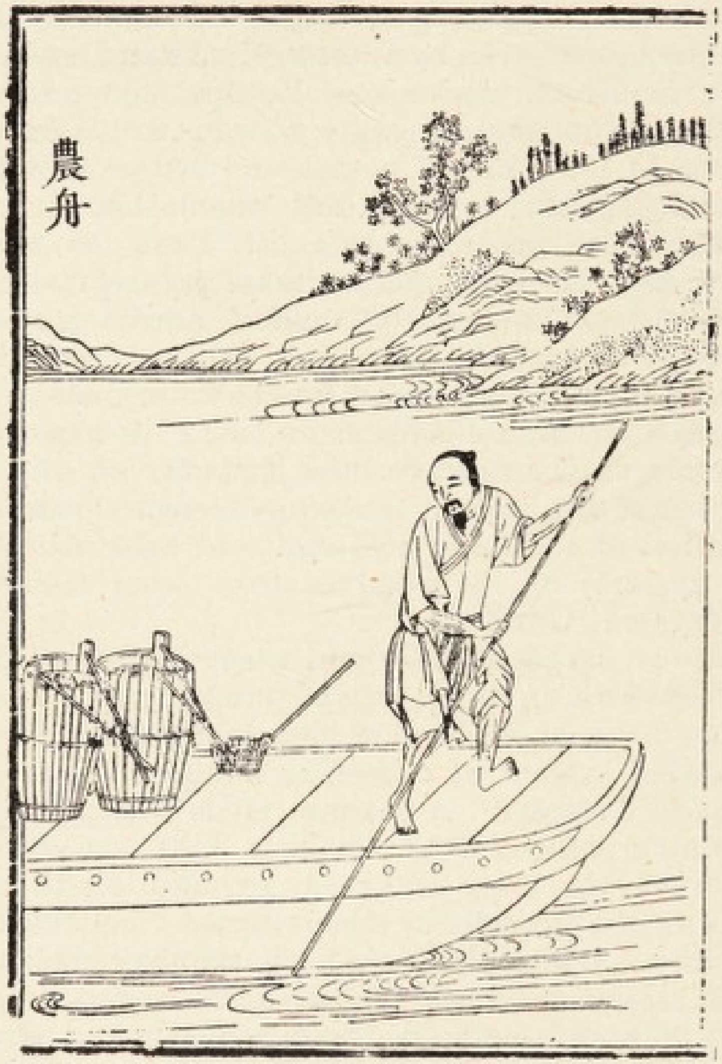


Fig. 75. — Transport of human excreta in China from the town to the rice field by "the farmer's boat".

(Reproduced from the work knows as *Ch'n ting shou shih t'ung k'ao,* the great treatise on agriculture produced by order of the Emperor CH'IEN LUNG, 1736-1796. Book 35, Sheet 8, back).

the principles of the English water-closet, in which the excreta are mixed with large quantities of water and not allowed to be collected in cesspits, which require very frequent emptying by artificial means. The water and the excreta are all passed into the drains (according to the "everything to the drains" system) or, where this system is not in vogue or it is impossible to transfer the matter straight to the drains, septic tanks with fermenting layers are utilized in order first to liquefy the unexposed faecal matter by fermentation and afterwards to purify the water by means of porous bacterian beds through fermentation, mainly nitric, while exposed to the air (1).

Many large towns have adopted the CALMETTE method for the purification of the water, arising from the " everything to the drains "

Fig. 76. — Manuring rice-fields in China with human excreta.
The manure is distributed among the seedlings by means of a small wooden bucket.

Reproduced from the work known as *K'ang-hsi yü chih kêng Ch'in t'u* or " Pictures of agriculture and silk-worm breeding published in 1696 " by the Emperor K'ANG-HSI (1662-1723). This very rare work in two volumes was presented to the International Institute of Agriculture by His Excellency the President of the Chinese Republic in 1920 (2).

system, a method which, while being quite the most satisfactory from the point of view of modern hygienic requirements, requires a heavy expenditure both for setting up the tank and engine plant

(1) Cf. A. BRUTTINI, Fossa settica con filtro biologico, in *L'Ingegneria sanitaria*, Year IX, No. 19. Milan, 1913.

(2) For more detailed information with regard to this work, cf. article by G. PERRIS in the *International Review of the Science and Practice of Agriculture*. Rome, September, 1921, No. 9, p. 1137.

and also for actual working. When it is not possible to collect the manure in a special cesspit, the "earth" system may be considered the best alternative, as it allows the excreta to be preserved and rendered odourless without any expenditure of water. This system is in effect that followed by armies in the field, though in this case the pits made in the open air are filled up and abandoned whereas on a farm they are periodically emptied of their contents which can be preserved in heaps either under cover or in the general manure heap (1).

During the war the adoption of the "earth" system was recommended to Italian farmers in cases where the land was lacking in fertilizers and had only sufficient water for the actual needs of the persons on the farm and the cattle, two types of reservoir with latrine attached being suggested. The first consisted of a pit encased in stone or well fitting baulks built above the soil level and provided with an opening for clearing. In the upper part, forming the floor of the latrine, is the opening and by its side a heap of fine clay soil, thoroughly dried (2). A slight roof and an entrance stair are also provided. Each time the latrine is used, a few handfuls of earth should be thrown down and all that remains is to empty the pit when full. The contents when kept under any form of shelter are soon converted into a homogeneous soil of great value as a fertiliser.

The general arrangements in the second type are identical except that the pit is below the ground level and has at least one side clear with an opening for clearing.

Such arrangements are of simple construction and inexpensive and, as they enable the excreta to be collected, soon repay their cost. A sketch is here given of a latrine and reservoir, generally resembling the types above described (see fig. 77). This is the class of earth closet in use at Westboro, Mass., U. S., since 1817 and the illustration is taken from an article on human excreta by G. M. WARREN (3).

It does not appear that during the war any very serious attempts were made to use on a larger scale than in the past the excrements which generally are almost entirely wasted so far as agriculture is concerned. Where however they were utilised they are still employed, and in many districts as for example in Central Italy the tendency has been, despite labour shortage, to increase their use, in order, if only partially, to make good the marked shortage of chemical nitrogenous fertilisers and the constant rise in their price.

The use of human manure is undoubtedly primitive and up to a certain point possibly unhygienic and the necessary improvements

(1) The "earth" system was recommended during the war in Germany by Professor HOFFMANN, an official of the Deutsche Landwirtschafts Gesellschaft. (German Farmers' Society).

(2) It is essential to use clay soil; sandy or gravelly soil is unsuitable as being insufficiently absorbent.

(3) 1) Geo. M. WARREN. Sewage Disposal on the Farm. *Yearbook of the Dept. of Agr.*, Washington, 1916, p. 347. — 2) Sewage and Sewerage of Farm Homes. *U. S. Depart. of Agriculture, Farmers' Bulletin*, No. 1227, January, 1922.

can only be brought about where it is possible to use modern methods of collection, transport and preparation on a large scale.

It may be worth while briefly to refer here to two kinds of refuse known as "Koufri", "Marog" and "Tafla" which have long been used in Egypt, and undoubtedly contain large quantities of human excretions (1).

"Koufri" is of distinct importance for agriculture both in Upper and Lower Egypt. It consists of the refuse accumulated in the ancient villages mixed with various kinds of organic detritus. Its chemical nitrogen content is the result of the almost complete absence of rain, which allows nitrification to take place without loss of nitrates. It is impossible to estimate the value of this refuse but it must be considerable and for many years it has provided a fertiliser to supplement the ordinary manure, large quantities being transported by means of the Nile to great distances. The mass is screened before loading to get rid of stones, fragments of brick etc. It is chiefly used in the cotton fields, but also for cereals and sugar-cane. The nitrogen content varies from 0.20 to 0.75 %, phosphoric anhydride from 1 to 1.75 %, potash from 1 to 2 %, chloride of sodium is also found in amounts varying from 0.5 to 9.4 %.

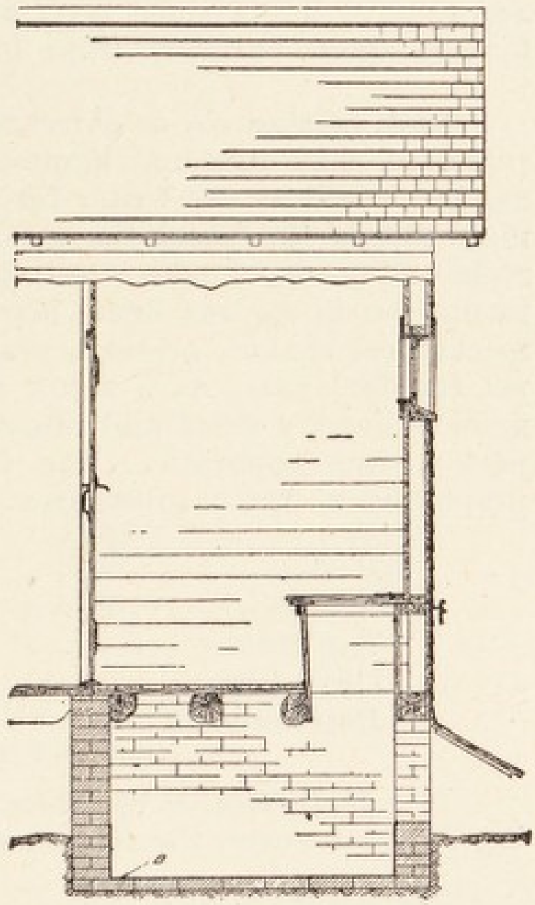


Fig. 77. — Privy working with dry soil or earth-closet longitudinal section.

Reprinted from U. S. Dept. of Agriculture Yearbook, 1916.

"Marog" or "Tafla" is found in Upper Egypt only, where it is largely utilised.

It consists of a limey clay, rich in nitrates and is found among the hills of the Southern Desert. It contains varying amounts (from 1 to over 16 %) of nitrogen in the form of sodium nitrate and in addition sodium sulphate (1.16 to 5.28 %) and sodium chloride (3.97 to 6.25 %). This high content in salts is a source of difficulty, which makes it necessary before using it as a manure to pay special attention both to its composition and also to that of the soil.

(1) Cf.: 1) GEO. P. FOADEN, Two Natural Nitrogenous Manures employed in Egypt. *Khedivial Agricultural Society*, Le Caire, 1905. — 2) MOSSERI, V. M., Influence du Koufri, du Marog et de la Tafla, in *Bull. de l'Union des Agric. d'Egypte*, No 150. Le Caire, 1923.

The best type of "Marog" is found on the surface, to which as a result of capillarity the nitrate rises: in practice 24 % of nitrate is often found at the surface and 3 % only at a depth of a foot.

Naturally the best sort of "Marog" pays well for carriage even to long distances. The natives take advantage of the capillary process and remove the topmost layer only, waiting until the uncovered surface is again enriched from below before taking further supplies.

Peat, sawdust etc. as absorbents for night-soil (1). — The absorbent power of peat dust and lignite, sawdust, tan refuse, olive lees, etc. has been used by the writer for the preparation of fertilisers of which night-soil is the base, the method adopted being as follows. The night-soil is mixed with a suitable quantity of one of the substances mentioned in an iron drum hermetically sealed which is fitted with a mechanical shaker, a steam heating tube and a suction pipe to expel the foul gas. As a result of nitration, heating and suction the mass is quickly dried and removed through an opening in the lower part of the apparatus. The following table shows the absorbent properties of these substances after air drying.

Peat	litres	500-700 %
Sawdust.	»	420-500
Tan refuse	»	400-500
Olive lees	»	160
Pulverized lignite	»	34

If it is desired to use them as absorbents for night-soil containing 95 % of water, the following quantities must be used:

For each 190 lbs. of:	lbs. of night-soil
Peat	526-726 %
Sawdust.	442-526
Tan-refuse	421-526
Olive lees	168
Lignite	36

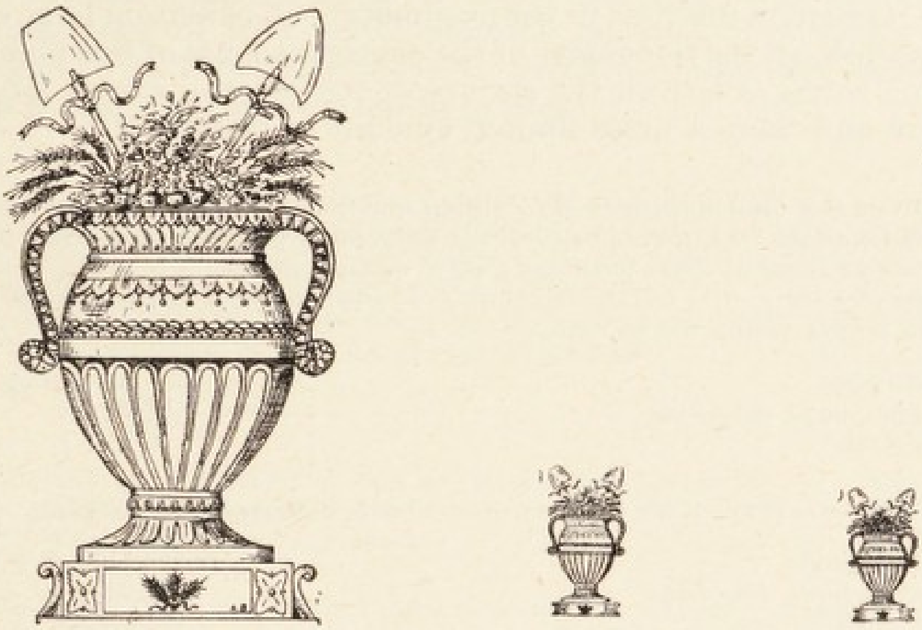
These figures might be considerably increased.

By using powdered lignite, which has the lowest power of absorption of the substances to which reference has been made, an almost odourless manure has been obtained, shown by Prof. S. Grimaldi's analysis to contain: nitrogen, 1.737 %, phosphoric acid, 1.09 %, potash 1.35 %.

In order to give some idea of the enormous quantity of fertilising material produced in human excreta throughout the world, most

(1) Cf. A. Bruttini, Fabbricazione rapida di concime a base di pozzonero e materie assorbenti, in *L'Agricoltura italiana*, Year XXIV, No. 383. Florence, 1898.

of which is lost to agriculture, the average figures are taken for the content of such material in faeces and urine per individual per day, *i.e.* nitrogen { 14.20 gm. / 0.5 oz. } phosphoric anhydride { 3.44 gm. / 0.125 oz. } potash { 2.95 gm. / 0.1 oz. }



A. B. C.

Fig. 78. — Diagram showing the relative amounts of fertilizing substances contained in the human excreta produced each year in 63 capital Cities (figures from the Table on pp. 294, 295).

A. *Nitrogen* — B. *Phosphoric anhydride.* — C. *Potash.*

Hence for a world population of 1,825,878,779 inhabitants (1) the figures are:

	Metric tons per day	Tons per year
Nitrogen	25,927	9,463,355
Phosphoric anhydride	6,281	2,292,565
Potash	5,385	1,965,890

If phosphoric acid alone be taken into account and it is reckoned that about 50 lb. will provide sufficient fertilising matter for 1 acre, the above total would suffice for an area of nearly 100 million acres.

The above figures give an idea of the vast quantity of fertilising material which might be derived from the world production of this form of refuse, but although the estimate is based on actual facts, it would be quite erroneous to consider that these huge amounts can in fact actually be used for manuring the soil. On the contrary the greater part

(1) Cf. International Institute of Agriculture, Statistical Year Book; 1917-18. Rome, 1920.

is in fact lost by infiltration, fermentation, and, in many important centres, by passage into drainage systems, rivers and the sea.

Apart from the really considerable utilisation of human excreta already described in China and their more limited employment in Flanders, Tuscany and elsewhere and taking also into account the use for purposes of irrigation of water derived from the "everything to the drains" system in districts in the neighbourhood of certain large centres of population, all the remainder of the enormous mass of this potentially fertilizing refuse is lost on the surface of the soil and can at most provide here and there a quite limited amount of manure (1).

(1) Given the total quantities of fertilising materials produced annually the present values can be established, taking as coefficients the following prices, calculated in *francs*; on the basis of those of trade fertilisers: (i. e. organic nitrogen 3 francs to 8,50 francs P^2 O^5 superphosphate, 1.15 fr.; K^2 O chloride of potash 50 %, 1.70 fr.) diminished by a third, and always taking the quotation:

Nitrogen.	2 fr. per kg.
Phosphoric anhydride.	0.77 fr. » »
Potash	1.10 fr. » »

and this will be obtained for the quantities above indicated, the following totals:

Nitrogen.	18,926,710,000 fr.
Phosphoric anhydride	1,765,275,000 »
Potash	2,162,479,000 »
Total . . .	22,854,464,050 fr.

This sum corresponds to 12.51 francs per annum for each inhabitant of the globe.

To illustrate this enquiry, intended as it is to give an idea of the immense quantities of fertilising elements which are in the main lost with human excreta it may serve the purpose to restate the total quantities of these elements in the corresponding quantities of the nitrogenous phosphatic or potassic chemical fertilisers, in ordinary use. Nitrate of soda may then be considered as 15 % nitrogen, mineral super-phosphate as 15 % soluble phosphoric anhydride, and chloride of potash as 50 % potash. It should be borne in mind that the condition and assimilability of these three nutritive elements are not precisely the same in human excreta and in chemical fertilisers but for purposes of comparison they have to be considered as identical. The reader who is acquainted with the properties and uses of the various fertilisers will form an estimate of the differences.

It would be fantastic to expect a complete utilisation of these residues, but in many cases they might be utilised more systematically and more intensively, especially for the fertilisation of land in the neighbourhood of the inhabited centres. This would afford the advantage of recovering — at least in part — a great source of wealth, at present practically lost to agriculture.

The following is the procedure for the transformation of the fertilising principles of the excreta into chemical fertilisers:

Nitrogen.	9,463,355	— Nitrate of soda (15-16 %) . .	63,089,033
Phosphoric anhydride	2,292,565	— Mineral superphosphate (15 %)	15,283,767
Potash	1,965,890	— Chloride of potash (50 %) . .	3,931,780
			82,304,580

One final statistical calculation:

Given the above quantities of nitrate of soda, of mineral superphosphate and of chloride of potassium, corresponding to the total quantities of nitrogen, phosphoric anhydride

The figures in the following table may however serve a useful purpose. They have been given for the purpose of indicating the possible advantage to many towns of making a proper use of human refuse for enriching the soil of the adjacent country side. It has been impossible to provide figures for all the larger cities of the world and hence the table is limited to the capitals of the states, which take part in the International Institute of Agriculture, as it is quite possible that these may be in a better financial position then others for carrying out the work actually required to make possble the employment of this material in the manner suggested.

and potash of the human excreta the area of land that these can fertilise may be calculated, taking as coefficients the following average doses to the hectare: nitrate of soda 200 kg. (0.30 kg. of nitrogen); mineral superphosphate 400 kg. (0,60 kg. of phosphoric anhydride: chloride of potassium 150 kg. (0.75 kg. of potash.)

[To the *acre*: 175 lb. of nitrate of soda (27 lbs. of nitrogen): 330 lbs. of superphosphate (50 lbs. of phosphoric acid): 130 lbs. (20 lbs. of potash)].

It thus appears that

	Hectares		Acres
Tons. 63,089,033 of nitrate of soda are enough for	315,445,165	—	788,612,862
» 15,283,767 of superphosphate » » »	38,209,417	—	95,523,542
» 3,931,780 of chloride of potash » » »	26,211,866	—	65,529,665

According to the International Yearbook of Agricultural Statistics in 1917-18 the productive area, that is the cultivated area, of the globe is 1,931,050,283 hectares (4,771,559,879 acres). The quantities above indicated stand to this area respectively as 1 : 6 ; 1 : 55 ; 1 : 73.

TABLE SOWING: THE POPULATION OF 63 CAPITALS, THE FERTILISING ELEMENTS PRODUCED IN THEM YEARLY, THEIR MONEY VALUE AND THE AREA THEY COULD FERTILISE.

	TOWNS AND THEIR POPULATION (1)		FERTILISING ELEMENTS			MONEY VALUE			AREA POSSIBLE TO FERTILISE		
			Nitrogen Daily production per person 14.2 gm.	Phosphoric anhydride Daily production per person 3.44 gm.	Potash Daily production per person 2.95 gm.	Nitrogen 2. fr. per kg.	Phosphoric anhydride 0.77 fr. per kg.	Potash 1.10 fr. per kg.	Nitrogen 15.38 kg. per acre	Nitrogen 24.28 kg. per acre	Nitrogen 30.35 kg. per acre
			long tons	*long tons*	*long tons*	*fr.*	*fr.*	*fr.*	*acres*	*acres*	*acres*
1	London	4,521,685	23,066	5,588	4,792	46,871,800	4,371,598	5,355,570	1,524,005	233,822	160,413
2	Paris	2,888,110	14,733	3,569	3,061	29,938,200	2,729,251	3,420,780	973,422	149,348	102,461
3	Tokio	2,244,796	11,451	2,774	2,379	23,269,600	2,170,322	2,658,810	756,596	116,084	79,638
4	Berlin	1,898,000	9,682	2,346	2,011	19,674,600	1,835,141	2,248,070	639,706	98,157	67,335
5	Vienna	1,842,000	9,396	2,276	1,952	19,094,000	1,780,856	2,181,740	620,829	95,253	65,348
6	Moscow	1,817,100	9,269	2,246	1,926	18,836,000	1,756,832	2,152,150	612,440	93,968	64,463
7	Buenos-Aires	1,637,000	8,351	2,023	1,735	16,969,200	1,582,658	1,938,860	551,743	84,652	58,073
8	Rio de Janeiro	1,150,000	5,866	1,421	1,219	11,921,000	1,111,803	1,362,130	387,603	59,467	40,800
9	Constantinople	1,000,000	5,101	1,236	1,060	10,366,000	966,812	1,184,480	337,044	51,713	35,477
10	Pekin	1,000,000	5,101	1,236	1,060	10,366,000	966,812	1,184,480	337,044	51,713	35,477
11	Budapest	880,000	4,489	1,087	933	9,122,000	850,773	1,042,250	296,595	45,505	31,220
12	Warsaw	820,000	4,183	1,013	869	8,500,200	792,792	971,190	276,379	42,404	29,090
13	Cairo	790,939	4,035	977	838	8,198,800	764,687	936,760	266,579	40,901	28,059
14	Madrid	648,760	3,309	802	688	6,725,000	627,242	768,460	218,659	33,550	23,018
15	Copenhagen	605,000	3,086	748	641	6,271,400	584,892	716,540	203,909	31,284	21,461
16	Rome	542,123	2,765	670	574	5,619,600	524,139	642,070	182,717	28,035	19,232
17	Mexico	471,066	2,403	582	499	4,883,000	455,455	557,920	158,768	24,360	16,712
18	Washington	437,000	2,229	540	463	4,530,000	422,499	517,550	147,289	22,598	15,501
19	Lisbon	435,359	2,221	538	461	4,513,000	425,882	515,680	146,738	22,512	15,447
20	Santiago	424,993	2,168	525	450	4,405,400	410,872	503,360	143,239	21,975	15,076
21	Stockholm	408,000	2,081	504	432	4,229,400	394,471	483,230	137,516	21,098	14,473
22	Dublin	403,030	2,056	498	427	4,177,800	389,620	477,400	135,838	20,329	14,300
23	Montevideo	382,700	1,952	473	406	3,967,000	369,985	453,300	128,983	19,788	13,579
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	121,338	18,615	12,771

27	Bucharest	310,000	1,581	383	329	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	Delhi	282,000	1,439	349	299	2,923,200	272,657	333,960	95,046	14,584	10,003
29	Christiania	259,445	1,323	321	275	2,989,400	250,866	307,340	87,444	13,418	9,205
30	Batavia	231,000	1,178	285	245	2,394,600	223,300	273,570	77,859	11,943	8,194
31	Tunis	176,500	900	218	187	1,820,600	170,632	209,000	59,489	9,126	6,259
32	Brussels	175,000	893	216	185	1,814,000	169,169	207,240	58,980	9,049	6,207
33	Algiers	172,400	879	213	183	1,787,000	166,705	204,160	58,103	8,916	6,116
34	Athens	167,479	854	207	177	1,736,000	161,931	198,330	56,445	8,661	5,941
35	Cape Town	165,000	842	204	175	1,710,400	159,544	195,470	55,612	8,533	5,854
36	Lima	143,500	732	177	152	1,487,600	138,754	169,950	48,369	7,421	5,090
37	Santa Fé	139,237	710	172	148	1,443,400	134,596	164,890	46,931	7,198	4,940
38	Berne	105,000	536	130	111	1,088,400	101,486	124,410	35,388	5,429	3,726
39	Sofia	103,000	525	127	109	1,067,600	99,561	121,990	34,711	5,325	3,655
40	Asunción	102,000	520	126	108	1,057,400	98,637	120,780	34,380	5,276	3,618
41	Saigon	100,000	510	124	106	1,036,600	96,712	118,470	33,703	5,172	3,548
42	Wellington	95,285	486	118	101	987,800	92,092	112,860	32,117	4,925	3,380
43	Belgrade	90,890	464	112	96	942,200	87,857	107,690	30,634	4,698	3,225
44	Guatemala	90,000	459	111	95	933,000	87,010	106,590	30,335	4,653	3,193
45	Ottawa	87,062	444	108	92	902,400	84,161	103,070	29,342	4,502	3,086
46	Addis Abeba	80,000	408	99	85	829,200	77,308	94,710	26,962	4,134	2,837
47	Tripoli	75,000	383	93	80	777,400	72,534	88,880	25,277	3,880	2,661
48	Quito	70,000	357	87	74	725,600	67,683	82,940	23,591	3,620	2,483
49	San Salvador	67,000	342	83	71	694,600	64,757	79,310	22,583	3,464	2,375
50	Antananarivo	65,000	332	80	69	673,800	62,832	77,000	21,909	3,361	2,306
51	Port Louis	50,000	255	62	53	518,400	48,356	59,180	16,855	2,587	1,772
52	San José	40,000	204	49	42	414,600	38,654	47,410	13,480	2,068	1,421
53	Rabat	38,000	194	47	40	394,000	36,729	44,990	12,810	1,965	1,347
54	Managua	34,900	178	43	37	361,800	33,726	41,360	11,765	1,804	1,238
55	Bengasi	30,000	153	37	32	310,800	29,029	35,530	10,104	1,552	1,065
56	Dakar	28,000	143	35	30	290,200	27,104	33,110	9,435	1,451	996
57	Luxembourg	20,217	103	25	21	209,600	19,558	23,980	6,815	1,045	719
58	Asmara	15,000	76	19	16	155,400	14,476	17,820	5,053	773	534
59	Mogadiscio	12,000	61	15	13	124,400	11,627	14,190	4,045	623	425
60	Cettigne	5,300	27	7	6	55,000	5,159	6,270	1,789	277	188
61	San Marino	3,524	18	4	4	36,600	3,388	4,180	1,188	180	126
62	Boma	2,500	13	3	3	26,000	2,387	2,970	845	128	89
63	Camberra	2,404	12	3	3	25,000	2,310	2,860	813	124	86
	TOTALS	31,923,304	162,944	39,477	33,853	331,415,200	30,825,157	37,834,270	10,766,276	1,651,842	1,133,234

(1) Cf.: The Statesman's Year-Book 1921, Macmillan and Co. London 1921. — (2) Calendario-Atlante De Agostini 1921, Novara, 1921.

39. — Utilisation of Sewage and Sludge (1).

The problem of nitrogen in excreted matter and waste products has two distinct aspects, their direct use a manure and the transformation of their nitrogen content into some form of commercial product.

But little use has been made up to the present of this second method of utilisation on account both of questions of technique and also of the disagreeable and unhygienic character of work of this order. The system of "all to the drains" makes the extraction of nitrogen a difficult matter by reason of the great mass of water involved.

The research work of the Sub-Committee of the Nitrogen Products Committee show that the figures which follow can be taken as general averages.

The amount of urine excreted by an adult male, weighing 11 stone, is 1500 cubic centimetres daily and contains 16 gm. of nitrogen. In the case of a woman whose diet contains 80 % of the protein of the diet of a man (118 gm) the nitrogen in the urine falls to 13 gm. daily. With children the average is 8 gm. per day.

In the solid excrement, the rate of nitrogen varies according to the nature of the diet: it is usually reckoned that 5 to 9 % of nitrogen is to be found in the faeces when fresh.

Assuming a population of 45 millions for the United Kingdom, 643 metric tons of nitrogen are produced daily or 234,000 metric tons a year, about 86 per cent. being contained in the urine.

(1) Cf. : 1) MINISTRY OF MUNITIONS OF WAR. MUNITIONS INVENTIONS DEPARTMENT. Nitrogen Products Committee. Final Report. London, His Majesty's Stat. Off., 1920, pp. 103 and 311. — 2) NASMITH G. and MC. KAY G. P. in *The Journ. of Ind. and Engin. Chem.*, vol. X, nº 5, Wasihngton, 1918. — 3) BRENCHLEY W. E. and RICHARDS H. in *Journ. of the Soc. of Chem. Ind.*, vol. XIX, nº 13. London, y 1920. — 4) KALOUCHSSKJI A. A., *C. R. du Laborat. d'Agron. de l'Inst. Agron. de Moscou*, Year 18, vol. IX, Moscow, 1914. — 5) AITA A. in *L'Italia Agricola*, Year 43, No. 11. Piacenza, 1916. — 6) INST. INT. D'AGRIC, *Monthly Review of Agricultural Information*. Nov., 1921, No. 1079. — 7) J. MAHISTRE. « L'Epuration industrielle et agricole des Eaux d'Egout ». *L'Ind. Chim.* Year 8, No. 95, 1921. — 8) « Sewage » in *Scientific American*, Feb. 1922, pp. 125. — 9) WILSON A., COPELAND W. R., MILLS HEISIG H., Activated Sludge Process, *The Journ. of Ind. and Ind. Eng. Chem.*, vol. 14, No. 2, 1922, p. 128. — 10) BELTZER A. *L'Ind. Chim.*, No. 98, Paris, 1922. — 11) A. CALMETTE. Recherches sur l'épuration biologique et chimique des eaux d'égout. Vol. 1-VII and supplement. Paris, Masson 1908 et seqq. — 12) Ditto. Epuration des eaux d'égout urbaines et industrielles. Paris, Barillière, 1910. — 13) S. RIZZI. L'epurazione biologica delle acque di rifiuto. Milan, U. Hoepli, 1915. — 14) F. LACCETTI, Fognatura biologica. Milan, U. Hoepli, 1915. — 15) A. MILLE. Assainissement des villes par l'eau, les égouts, les irrigations. Paris, V. Ch. Dunod, 1886. — 16) L. FABRE. « Le traitement de l'eau d'égout » *Chimie et Industrie*, Vol. 7, No. 6, Paris, 1922, p. 1196. — 17) DAVERTON A. « Assainissement des villes et égouts de Paris ». Dunod, Paris 1922. — 18) Durchlüftungsdauer beim. aktiv. Schlamprozess, *Gesundheits-Ingenieur*, No. 12, p. 162. Munich, 1922. — 19) Le traitement des eaux d'égout par boues activées à Milwaukee, E. U. *Génie Civil*, No. 23, Paris, 1922. — 20) Sludge reduction at the Baltimore sewage treatment plant. *Public Works*, No. 12, N. Y., 1922, p. 209.

A bibliography with analyses is to be found in the following publication : *Union Intern. des Villes. Tablettes docum. munic.* S. III. Eaux, égouts, eaux résiduaires, etc. Brussels, 1921 et seqq.

The annual production of ammonia in the United Kingdom in 1911-1913 expressed as sulphate of ammonia (25 % NH_3) was about 82,400 metric tons while the average consumption of sulphate of ammonia and nitrate of soda showed about 25,000 tons of nitrogen content. Hence the average annual amount of nitrogen excreted by the inhabitants is 9 times as much as that in use before the war in the form of these fertilisers and about three times higher than the average amount of ammoniacal nitrogen produced at the time.

It must also be borne in mind that considerable quantities of nitrogen are lost in the excreta of animals as well as in the liquid wastage from certain special industries including the preservative treatment of timber and the manufacture of glue.

The Sub-Committee to which reference has been made states that only half the population of the United Kingdom discharges its excreta into the drains ; in the case of the remaining half they are ultimately used as manure though a large amount of the nitrogen content is lost in the liquid matter of the cesspools.

In London for example the sewage water is clarified and discharged into the Thames while the sludge is carried out to sea. At Manchester there are septic tanks with filter beds and the sludge is also carried out to sea. Other sea-board towns discharge their sewage into the sea either with or without previous deposit of the solid material.

Sewage water contains on the average five hundred thousandths of ammoniacal nitrogen and two to two and a half hundred thousandths of organic nitrogen with forty hundred thousandths of organic and mineral matter in suspension. At present the nitrogen in solution can only be used for purposes of irrigation and infiltration on special "sewage farms" and the sludge deposit is manure for land under cultivation when but little water is required.

As the assimilation of nitrogen by plants is dependent upon temperature, sewage water should in general be utilised during the warmer months. During the cold and damp period of the year nitrogen, chiefly in the nitric but also in the ammoniacal form, descends and is involved in the drainage system, such losses being inevitable.

It may be possible in the future to discover reagents at a moderate cost, which will precipitate the ammoniacal and nitric nitrogen in the sewage water and thus avoid the present immense loss of nitrogen.

Of the solids 30/100000 in suspension in the sewage water $^2/_3$ are combustible. In the process of precipitation they form different types of sludge: "settled sludge", "precipitation sludge", "septic tank sludge" and "activated sludge". Allowing for a 90 % water content, the following figures show the production of moist sludge in dry weather per million gallons of sewage water.

a) Deposit in still water, without reagents	12 tons
b) » » running water, without reagents . .	11 »
c) » » still water, with reagents	17 »
d) » » running water, with reagents . . .	16 »
e) septic tanks	6.5 »

Taking as a base an average of 30 gallons of sewage water per individual and per day, the corresponding daily production of sludge for a town of 100 000 inhabitants would be:

a) 36 tons
b) 33 »
c) 88 »
d) 48 »
e) 19.5 »

If the humidity of the sludge is reduced to 30-20 % the nitrogen content reaches 1-2 % but in a not readily assimilable condition, probably as a result of the fatty matter, which is always present.

Sludge utilisation. — One method consists in pumping the semi-liquid sludge and allowing it to flow along shallow trenches, made in absorbent soil. When the water has evaporated and the sludge is relatively dry the trenches are filled up and, if the soil is suitable and the amount of sludge not excessive, the soil is well fertilised and gives satisfactory crops.

Under another system the sludge is mixed with lime and the water expressed by appropriate means; in this way briquettes are made, which contain a large amount of lime and 60-80 % of water. The briquettes are used as fertilisers but are of no great value as they are not pulverisable and contain fatty matter in a saponified condition.

The addition of calcium to precipitate the albumins much increases the deposit and does not diminish its fertilising value. In fact for a sludge obtained FABRE reports the following percentage composition: ash 67.82, ammoniacal nitrogen 0.068, organic nitrogen 1.76, phosphoric anhydride 0.83, lime 31.98, potash 0.12, fat 1.89. The clarified liquid also if discharged into a river reprecipitates the lime in solution as carbonate and the albuminoids become once more soluble.

Better results are secured by decantation or by the separation of the sludge by means of filters. The resulting filtration water is rich in fertilising elements and therefore well adapted for irrigation purposes. Its chemical composition is naturally very variable, e. g. in one cubic metre there were found: ammoniacal nitrogen 21.61 gm., organic nitrogen 7.66 gm., nitric nitrogen 0.73 gm., phosphoric anhydride 12 gm., potash 45.95 gm.

Sludge can also be used directly as a manure, if dried and pulverized. The drying is done in rotatory ovens with gas circulation at not more than 150° to 200° C. This operation is however only convenient when the transport of the dried sludge is not too costly.

If fermenting elements are added as in the case of "activated sludge" the percentage of water is reduced to about 82 and the sludge is then dried for use as manure, its nitrogen content being 2 to 2.5 %. Mention may also be made of the process of fat extraction from the sludge before its use as a fertiliser. After drying, sulphuric acid is used for acidification, the fatty acids are distilled and subsequently the residue in combination with phosphate of lime can be used for manure.

Activated sludge. — This form of sludge is prepared by mixing fresh sewage water with a small quantity of active sludge with the object of bringing about an inoculation with the contained ferments and then introducing a current of air into the liquid for several hours over porous tiles. The bacterial oxidation can be checked when the charcoal is fully oxidised or continued according to the type of effluent it is desired to obtain.

The force necessary to drive the air current entails a heavy expense while the presence of fatty matter seriously hinders the process. The chief feature in the process is the rapid oxidation of the organic matter combined with the destruction of harmful bacteria ; the nitrogen is nitrified and thus brought into a condition in which it is readily assimilable by the plants. Sludge treated in this way has a content of 4 to 6 % of nitrogen and distinct traces of phosphoric acid. The problem of drying this sludge is of very material importance economically as the whole fertilising value of the sludge, including the value of the bacterial inoculation, can be utilised by means of a pumping system, by which it is carried direct to the fields in the neighbourhood of the place of treatment.

The system is now in use at Manchester, Salford, Worcester and Stanford in England and also in certain parts of the United States.

In the United States activated sludge containing 2.46 % of phosphoric acid and 2.50 % of nitrogen in a comparative test with ordinary manure showed the following improvements in yield :— 40 % with radishes, 103 % with lettuces, 77 % with haricots, 138 % with beet-roots, 291 % with tomatoes, 554 % with onions. In a second experiment activated sludge was applied six times as freely as nitrate of soda and proved twice as effective. Up to the present however the difficulty of eliminating the 98 % of water from the activated sludge resulting from the process of sedimentation has not been overcome.

Recovery of Ammonia. — The chief systems in use include some form of distillation which is applied wherever it is possible to have a sufficient degree of concentration in the sewage water which is too dilute under the present sanitary systems.

In Paris, for example, the daily collection of urine and similar refuse which amounts to 2200 cubic meters is first partly disinfected and afterwards collected in large tanks for fermentation and storage. The process takes from three to four weeks to complete and the urea is converted into ammonia carbonate and other ammoniacal compounds. A large quantity of nitrogen is lost during the fermentation. The clear liquid is poured off and the contained ammonia distilled while the sludge is converted into manure. The ammonia is extracted in the sulphate form with a production of over 10,000 tons.

Another method employed is that of the chemical treatment of the sewage water in tanks so as to obtain a rapid sludge precipitation. Milk of lime is chiefly used (specific weight 1.16-1.20) and kept in constant motion : the clarified liquid is poured off and replaced by further addition of sewage water until the reservoir is full of sludge. The ammonia content of the liquid is distilled and the sludge heated with filter presses, By this means 100 cubic metres of sewage water have been made to yield 75 cubic metres of clear liquid and 25 cubic metres of sludge weighing after filtration 6 to 7 tons with 50 % of water. This form of sludge has little value as a fertilising agent.

Yet another method consists in separating the sludge from the clear liquid from which the ammonia content is distilled, while the sludge is collected in closed tanks equipped with rockers where it receives treatment with ferric chloride, aluminium chloride and phosphate of lime. After 24 hours filter pressure is used and the sludge converted into briquettes containing 3 to 3,5 % of nitrogen and 10 to 12 % of phosphoric anhydride assimilable in the form of bicalcic phosphate so as to be utilisable as manure. The distillation of ammonia from sewage to which lime is added is carried out extensively in Amsterdam where the plant is capable of dealing with 50 tons at a time. The sewage water contains 2.018 % of free and 0.326 % of fixed ammonia of which 0.008 % remains after distillation. For the treatment of 8750 tons of sewage water 123 tons of slaked lime, 153 tons of coal and 72 tons of sulphuric acid are required with a resulting production of 72 tons of ammonia sulphate. The solid residue mixed with lime and after passing through the filter press contains 58 % of dry matter 52.27 % of carbonate lime, 0.518 % of nitrogen, 0.155 % of potash and 0.157 per cent. of phosphoric anhydride. The Ministry of Agriculture in Russia decided in 1914 that a study should be made of the best means of utilising drainage sludge. The qualities investigated shewed a content of 12.3 gm. nitrogen per gallon, 71 % of which was in the ammoniacal form. Large quantities of the nitrogen were lost through exposure to the air amounting to 67.76 % in 95 days. The best method of extracting the ammonia was found to be a preliminary boiling followed by treatment with lime in the proportion of 5 gm. per litre.

Sewage water is used in Italy for irrigation, Milan being a notable example. After standing for a while all the ammonia is held in solution, while a muddy layer is deposited containing 80 to 90 % of water. For the liquid which contains three parts per thousand of ammoniacal nitrogen 1.5 kg. of ammonia sulphate were obtained per cubic metre by distillation with 44 lb. of coal. It was suggested that the ammonia might be liberated by air pressure but only 20 % could be recovered in this way.

The sediment also contains fatty matter, varying from 3 to 26 % of the dry weight, which is removed in England and Germany. The general composition of the sludge and hence its yield in by-products remains fairly constant where the sewage water comes entirely or almost entirely from dwelling houses though there is considerable variability in districts which contain factories.

The British Ministry of Agriculture has lately undertaken preliminary investigations with a view to determining: if the "activated sludge" permits of the utilisation of a large quantity of nitrogen of sewage waters in comparison with the other methods ; if the nitrogen it contains is more assimilable by plants, and what is the origin of the high degree of nitrogen of "activated sludge".

The results shew: 1) that with "activated sludge" there is obtained a recovery of 15 % of nitrogen while 10 % is recovered by the precipitation method and 4 % with septic tanks; 2) that the assimilability of the nitrogen of the sludge is considerably increased and that it is richer in phosphoric anhydride than sludge non-activated. From experiments made on flood land with two different sludges containing 90 % of water it results that for an equal content of nitrogen activated sludge gives good results, taken in comparison with the ammonium sulphate of that of stable manure. However the nitrification of the nitrogen of activated sludge requires double the time necessary for sulphate of ammonia. In conclusion activated sludge has given evidence of a high fertilising power.

The English Sub-Committee arrived at the following conclusion: the amount of sludge with a 50 % water content that can be obtained annually per 1000 inhabitants is 100 tons and the total amount obtainable in a year from the towns in the United Kingdom with a population of over 100,000 is approximately 1,800,000 tons from which there can be extracted say:

22,000 tons of Sulphate of Ammonia
54,552 m^3 of Tar.
22,730 m^3 of Light Oil.
500,000 tons of solids for manuring.

As regards capital and running expenses and the daily receipts accruing from thus handling the sludge the Sub-Committee gives examples of two typical plants, one on a large scale and the other relatively small; the first is suitable for dealing with the drainage residues of the Crossness area of the London County Council, the other might serve towns like Glasgow or Sheffield (1).

The figures are given in the following note and show the economic advantage of large installations.

In these general conclusions upon the process viewed industrially the Sub-Committee rightly draws attention to the high degree of heat required for the preliminary drying of the sludge the degree of moisture of which has to be reduced from about 70 % to 20 %. Moreover it does not appear, at present at any rate, to be worth while to recover

(1) Previous figures are given raised by 30 %. They are probably somewhat too low for present conditions (*Author's note*).

	Large Plant	Small Plant
	£	£
Machinery for drying the sludge. Furnaces and accessories. Machinery for dealing with by-produced. Buildings . .	144,410	31,777
Running expenses per day.	184	52
Gross receipts per day	371	62

the nitrogen in the urine (which represents 80 % of the total nitrogen in the excreta) as it is so highly diluted, especially when the urine is discharged into the drains which contain all kinds of other waters.

The distillation method described above could only affect the production of nitrogen compounds in the United Kingdom to a very small extent. As a matter of fact the faecal matter produces annually 32,900 metric tons of nitrogen of which one half only passes into the

FIG. 79. — Chinese field covered with small heaps of canal slime just brought up by means of three sets of steps made of earth. The quantity of slime here is upwards of 70 tons per acre. In the background a compost mound.
Taken from F. H. King, op. cit.

sewage water and is equivalent to about 82,000 metric tons of sulphate of ammonia.

The quantity of sulphate of ammonia which might be obtained from the drain water of the English towns with over 100,000 inhabitants does not exceed 22,000 tons or about 5 % of the pre-war production of ammoniacal compounds derived from by-products (1).

Slime. — This deposit to which a brief reference may conveniently be made at this stage in connection with the subject of sludge

(1) For the various methods of purifying sewage water, cf. KOLLER Dr. TH., op. cit. p. 28 et seqq.

and sewage is found at the bottom of ponds, pools, drains, ditches, etc., and is the result of a mixture of soil with various organic substances.

In many countries the slime is utilised as manure, after exposure to the air, fermentation and drying. It is also used for making composts.

In the Far East and especially in China canal slime is largely employed either directly or in the preparation of composts with grasses, clover, etc., chiefly for use in the rice fields (see fig. 79). This use of slime following on the extensive employment of human excrement plays an important part in keeping up the fertile character of the Chinese soil.

40. — Town Refuse and Street Sweepings (1).

These include the garbage of all kinds found in street sweepings and household refuse. They contain the following :— vegetable leaves and husks — fruit skins and kernels — pieces of hay, straw, wood, paper, leather, etc. — fish bones — shells of crustaceans — ashes, horse and poultry dung, etc. — corks — bits of glass, stone and croockery — rags — hair, feathers and skins — slime and soil — tins and other waste metal — mineral and organic dusts, etc.

As a result of this heterogeneity the chemical composition of this refuse is extremely variable and is affected by its character and that of the weather at the time of collection : for example, in dry weather, town refuse contains much less water than during a rainy period. The time of year is also an important factor ; in summer vegetable and fruit waste predominate while in winter there is more dry matter and a great increase in the amount of ashes.

Speaking generally town refuse requires an expenditure for transport and handling quite out of proportion to its beneficial action as a fertiliser. Its fertilising power, however, tends to increase with fermentation by which it is converted into the "black" form thus covering the cost of carriage for a certain distance, the volume being markedly reduced in comparison with that of the "green" or freshly gathered sweepings. The direct use of the refuse for agricultural purposes is the most ancient and the simplest for bringing about their disappearance. During the war the use of town refuse increased considerably in many quarters and it was also adopted for the first time as a fertiliser.

(1) Cf. : 1) A. Bruttini, *I Concimi*. Casale, 1912. — 2) D. Tamaro, « Utilizzazione delle spazzature e dei rifiuti animali », in *Il Coltivatore*, No. 15-16. Calsalmonferrato, 1919. 3) Rozous P., *Collecte, transport et traitement des déchets urbains*. Paris, Dunod et Pinat, éd. 1911. — 4) Schroeder P. I., « Les immondices dégraissées comme engrais », in *The Journal of Industrial and Engineering Chemistry*, Easton, Pa., 1917. — 5) Browning P. E., « Valeur fertilisante de quelques déchets domestiques », in *The Journal of Industrial and Engineering Chemistry*, Vol. 9, No. 11. Easton, 1917. — 6) Koller Dr. Th., op. cit. — 7) Ashbrook F. G. and Wilson A., Feeding Garbage to Hogs, *Farmer's Bull.* 1133, *U. S. Dept. of Agr.*, Washington, 1920. — 8) Daverton A. Assainissement des villes et égouts de Paris. Dunod éd., Paris, 1922, p. 188. — 9) Mount H. A. Garbage in Working Clothes, in *Scientific American*, Aug. 1922, p. 106. — 10) London refuse problem, *The Cleansing Superintendent*, Edinburgh, 1922, p. 202.

Experiments were also made with simple new methods of treatment. For example at Trieste, the sweepings which amounted to 90 tons daily were mixed with the excreta of horses and other animals and the whole converted by a process of fermentation into an earthy substance and sold for 20 *kronen* per ton at the depot. Part of the sweepings after the elimination of the non-combustible material was burnt in continuous furnaces, the ashes being plunged at once into water and then pulverised and sifted. The finer part was used as a fertiliser and the heavier as a substitute for sand in ferro-concrete or cement bricks. The finer powder which acted as a phosphatic manure was sold at 3 kronen per ton.

A patent for the following process has been taken out by A. D. Furse of Beckenhain.

Household refuse or dry sewage sludge or the two combined are mixed with 15 % to 20 % of fish or meat offal, 15 % to 20 % of bone meal after extraction of the gelatine and 15 % to 20 % of vegetable refuse containing potash, for example that of beetroots, sugarcane, tobacco, or bananas. The mixture is first heated with dilute sulphuric acid, then dried, pulverised and sifted. The destruction of town refuse by mechanical, physical or chemical means is only indicated where the towns are not surrounded by an expanse of field land sufficient to allow its general diffusion, that is to say an area eight times as large as the urban area itself, which allows for the diffusion of 10 to 12 ½ tons per acre every two or three years.

The following methods of industrial treatment are at present employed in various places: 1) treatment by steam or water at 150° C to separate the fat content. About half the heat necessary is supplied by the fermented and dry refuse. Steam treatment in the hot chamber lasts from 5 to 7 hours. The condensation water is then drawn off and with it is removed all the fatty matter which can be used for soap making or as a lubricant. The solid residue is submitted to pressure and dried by steam in large cylinders so that it is easily reduced to a fine powder resembling charcoal and odourless. This part which is known as *tankage* represents 12.5 to 18 % of the mass of refuse treated, of which the content is 77-83 % water, 2.5-5 % fats, *tankage*, 12.5-18 %. This method is applicable only to the case of the larger towns as the initial capital cost is heavy, but it possesses the merit of avoiding the sanitary risks caused by an accumulation of fermenting refuse matter and also of giving a homogeneous odourless form of manure, easily carried and handled, which does not introduce into the soil either the seeds of noxious weeds or fragments of glass or metal which are likely to injure the animals. In the United States there are 39 companies engaged in extracting the fat from household refuse or garbage, representing about half the larger towns. In 1914, 1,088,622 tons were treated and yielded, in addition to the fatty matter, 156,943 tons of fertiliser in the form of tankage. The refuse is treated by the following process: 1) sifting, 2) steam heating with the collection of the water and separation of the floating fats, or 3) drying with extraction by means of benzine and fermentation of the residue.

The water extracted is reduced to a siropy consistence and called "stick". It is mixed with dry tankage and converted into a powder of which the following is the percentage content : water 3.67 — ash 29.15 — fats 4.92 — potash 0.80 — nitrogen 2.78 — phosphoric anhydride 3.56. Forty per cent. of this nitrogen is assimilable and about 0.25 % water soluble. Solubility can be materially increased by treatment with sulphuric acid (1).

2) Another method of treatment followed in certain towns in Germany, the United States, Belgium, England and Austria consists in burning the refuse for the sake of the ash but in this way the whole content in organic matter and nitrogen is lost. Certain advantages, however accrue from the utilisation of the heat required for the combustion. The ash makes a clinker and attempts have been made to use it in cement and concrete bricks.

With TOBIANSKY's method of low temperature incineration with limited exposure to the air a brown powdery ash is obtained which can be used as a fertiliser.

During the war experiments were made on the use of fat free refuse as a cattle food after separation of the light from the heavier matter by a water test.

When town refuse is used directly as manure as is the case in many districts it may be considered as a low potency fertiliser. Analyses have given the following results.

	Water	Ash	Ether extract	Potash	Nitrogen	Phosphoric anhyd.	Combustible matters
Untreated refuse. . .	73.78 %	3.60 %	5.32 %	0.27 %	0.70 %	0.43 %	22.63 %
Treated refuse. . . .	3.67	29.15	4.92	0.80	2.78	3.56	—

The following are the quantities of potash and of phosphoric acid found in the ash of various household refuse (2).

(1) Cf. P. J. SCHROEDER, *Ind. Eng. Chem.*, No. 9, 1917.

(2) A lengthy treatise on collection, handling and utilisation of street refuse which may still be usefully consulted is that of P. FREDA entitled « Importanza delle Immondizie della Città di Roma per l'agricoltura locale » published in *Le Stazioni sperimentali Agrarie Iliane*. Vol. XXII. Part. 5. 1892.

Sir E. J. RUSSELL, Director of the Experimental Station of Rothamsted in a recent publication notes that in England and Wales the street sweeping amount to not less than 10 million tons per annum, and in London alone to 1,900,000 tons. The English towns spend annually on the collection and distribution of the sweepings about 6 million sterling. In some cities of the North of England the sweepings are enriched with a considerable quantity of the scourings of sewers, the refuse of cattle markets, slaughterhouse offals, and stable litter, thus yielding an excellent fertiliser with one or more per cent of nitrogen. (Cf. E. J. RUSSELL. The Possibility of using town refuse as manure, *The Journal of the Ministry of Agriculture* Vol. XXIX. No. 8, 1922. p. 685).

Ash of	Potash	Phosphoric anhydride
Banana stalks	49.40 %	2.34 %
Banana skins	41.76	3.25
Orange peel	27.00	2.90
Lemon peel	31.00	6.30
Apple peel	11.74	3.08
Rind of melon	12.21	9.77
Rind of cucumber	27.20	11.28
Fresh potato parings	27.50	5.18
Pea-pods	9.00	1.79
Used tea leaves	0.44	1.60
Coffee grounds	0.67	0.36
Egg shells	0.29	0.43
Peach stones	6.04	3.25
Peach peelings	30.76	6.31

Kitchen refuse, dried and ground, is especially suitable as binding material for horticultural composts.

41. — Nitrate Fertilisers from Residues treated with Bacteria. Humogene (1).

During the war, as it was well known that the nitrogen-fixing and nitrifying bacterial flora of the soil are only active where organic matter is present, the question arose of the possibility of the employment of certain organic forms of waste material, such as molasses, grape residues, straw, paper, wood, weeds, sugar refining residues, etc., after treatment with symbiotic nitrogen-fixing bacteria selected for their high degree of activity, such mixtures being subsequently well stirred and dried.

In 1915, at the request of the British Ministry of Agriculture, Dr. E. J. RUSSELL undertook a series of experiments with Professor BOTTOMLEY'S *Humogene* (2).

This fertiliser is made of sterilised peat, after bacterial decomposition, and inoculation with nitrogen-fixing micro-organisms.

It was used by E. J. Russell in doses of 1.25 metric tons on fodder beets, kitchen garden plants, mustard and barley grown in pots. All the experiments had a negative result and the conclusion was that humogene has no special agricultural value, as it is not superior to any other organic fertiliser with the same nitrogen content. This

(1) Cf. 1) DARYLAND C. Engrais azotés fabriqués avec des déchets, in *Abstracts of Bacteriology*. Vol. II. Baltimore, 1918. — 2) ADINARRAYAN RAO K., A New Source of Manure in *The Agr. Journ. of India*, Vol. XVII, p. V, Calcutta, 1922, p. 476.

(2) Cf. RUSSELL E. J. Humogene in *the Journal of the Board of Agriculture*, Vol. XXIV. No. 1. London, 1917.

fertiliser may be sometimes useful to gardeners in preparing mould for repotting, being for this purpose the equivalent of untreated peat and used in the same proportion.

The proportion of nitrogen in humogene varies considerably, fluctuating between 0.4 and 1.3 %.

There is in effect no evidence to show that the treatment devised by BOTTOMLEY increases the fertilising value of peat.

Previous experiments with humogene had generally given the same unfavourable results, which are inconsistent with those obtained by the inventor himself: he maintains that humogene is really an effective fertiliser.

In Germany experiments were made during the war with a fertiliser called *Guanol*, composed of lees of molasses mixed with peat and inoculated with *Azotobacter*. It was tested also in the sterilised form, so as to ascertain the action of the bacteria. These had transformed 88 % of the betaine, which only formed 1.6 % of the dry matter. The nitrogen of the peat is inactive; that in the lees is alone effective.

The yield was the same with the sterilised *Guanol*: and hence the bacteria have no real effect.

In eight weeks, 30.04 % of the nitrogen of *Guanol* had nitrified (1).

Important experiments were made in India (2) with the residual pulp from sugar manufacture (*megasse*) which is as a rule burnt. It contains about 40 to 50 % of water, 10 % of non-extractable sugar and 40 to 50 % of fibre. In India 20 to 25 million tons of this residue are available annually.

The treatment with nitrogen-fixing micro-organisms can be carried out in three ways: 1) by inoculation with the nitrogen-fixing bacteria alone; 2) by preliminary introduction of micro-organisms which decompose the cellulose, subsequent sterilisation and then inoculation with the nitrogen-fixing bacteria; 3) the simultaneous introduction of both kinds of micro-organisms. The sugar produces 100 milligrammes of nitrogen per 10 gm. of cane pulp, after a single fixation.

Pulp thus treated after two months contained 1.39 % of nitrogen, i. e. more than double the nitrogen content of stable manure.

This method is also recommended by the author for residues of the following: prickly pear, dry leaves, straw, sawdust, etc.

42. — Chemical composition of various waste products.

Analyses have already been given above for each of the waste products in turn, and the following table, extracted from the Yearbook of the United States Department of Agriculture (3) and from WOLFF's tables (4), is added for completeness of reference.

(1) Cf. KOCH, in *Fuhling's Landwirschaftliche Zeitung*, Year 65, No. 5-6. Stuttgart, 1916.

(2) K. ADINARRAYAN RAO. A New Source of Manure, in *The Agric. Journal of India*, Vol. XVII, part V. Calcutta, 1922, p. 476.

(3) Cf. C. C. FLETCHER, « Conservation of fertilizer materials from minor sources », in *Yearbook of the Department of Agriculture*, Washington, 1917 p. 283.

(4) Figures marked with asterisk.

	Nitrogen %	Phosphoric anhydride %	Potash %
Vegetable waste products :			
Cotton : Bolls.	—	8.70	23.93
Spinning waste	1.32	0.45	0.36
Sweepings of cotton seed mills .	1.37	0.68	1.56
Cocoa : Hulls	1.04	1.49	2.71
Tea : Used Leaves	4.15	0.62	0.40
Coffee : Grounds	2.08	0.32	0.28
Castoroil seed : Cake.	5–6	2–2.5	1–1.25
Apples : Ash of peel	—	3.8	11.74
Grapes : Residues	0.75	0.20	0.40
» Ash of skins	—	3.58	30.60
» Lees *	1.31	0.36	3.34
» Stripped Stalks *	—	0.18	1.09
» Residues *	—	0.46	1.72
» Vine shoots *	0.41	0.14	0.41
Bananas : Ash of skins.	—	2.34	49.40
Water melons : Ash of rind	—	11.28	27.20
Lemons : Ash of peel	—	6.30	31.00
Oranges : Ash of peel	—	2.90	27.00
Nuts : Shells	0.80	0.15	0.50
» Ash of shells	—	1.23	6.45
Barley : Fresh brewers grains	0.90	0.50	0.05
Maize : Dried stems *	0.48	0.38	1.64
» Charred stripped stalks.	—	—	2.01
» Ash of stalks	—	—	50.00
Wheat : Straw	0.50	0.15	0.60
» Husk *.	0.72	0.40	0.84
Buckwheat : Straw *	0.78	0.18	1.23
Beans : Straw *.	1.63	0.29	1.94
» Pods *	1.68	0.27	3.55
Lupin : Straw.	0.94	0.25	1.50
Potato : Haulms.	0.60	0.15	0.45
» * » *	0.49	0.16	0.43
» * Ash of cooked parings.	—	3.29	13.89
Jerusalem artichoke : Dried stems . . .	0.43	0.07	0.41
Colza : Straw *	0.50	0.27	0.97
» Pods*	0.83	0.36	0.57
Poppy : Straw *.	0.40	0.23	2.00
Tobacco : Stems	3.70	0.65	4.50
» Dried Leaves *	3.48	0.66	4.09
Tomatoes : Leaves	0.35	0.10	0.40
» Stems	0.35	0.10	0.40
Oak : Leaves	0.80	0.35	0.15
» Ash of tan	—	4.99	18.03
Wood : Sawdust	5–6	2–4	1–3
» Fresh ash	—	1–2	4–10
» Lixiviated ash.	—	1–1.5	1–3
Lees of Molasse.	0.70	—	5.32
Animal waste products :			
Bones :	2.5–4.5	20–25	—
» Ash	—	34.70	—
Dried blood	10–14	1–5	—
Tankage	11–12.5	1–2	—

	Nitrogen %	Phosphoric anhydride %	Potash %
Bats' excrement.	1–12	2.5–16	—
Eggs : Calcined shells	—	0.43	0.29
Fish : Fresh offal	2–7.5	1.5–6	—
« Dried »	7.76	13	0.38
Slaughterhouse offals (New York).	3.4–3.7	1–2.47	2.25–4.25
Leather : Clipping	6.88	—	—
« Ash of clippings	—	2.16	0.35
Ground horns and hoofs	10–15	1.5–2	—
Wool : Rags and felt	4–12	—	—
« Spinning waste	4.4	0.20	0.68
« Felt manufactory waste.	13.00	—	0.98
Silk worms : Chrysalides	9.42	1.82	1.08
» » Silk	8–11	—	—
» « Silk spinning waste	8.37	1.14	0.12
Shell fish : offals	4.50	3.50	—
» » shells	4.60	3.52	—
Mineral waste products :			
Slime : fresh water	1.37	0.26	0.22
» harbour	0.99	0.77	0.05
Limekiln ash	—	0.75	2.00
» » *	—	0.5–1	1–1.5
Soot	—	1.05	0.35
Gunpowder : waste from manufacture . . .	10.28	—	34.50

The following table contains other figures relating to the utilisation of residues in the United States for the manufacture of fertilisers.

Residues	Water	Lime	Phosphoric anhyd.	Total nitrogen	Soluble nitrogen	Insoluble assimilable nitrogen	Insoluble non-assimilable nitrogen
Sheep dung with wool waste . . .	4.99	2.89	0.31	1.27	0.51	0.30	0.46
Wool waste with fat removed . .	44.80	0.37	0.03	1.30	0.27	0.51	0.52
	—	—	9.90	8.60	2.08	3.43	2.65
Seaweed	15.66	1.81	0.23	0.60	0.09	0.15	0.36
Raw kitchen refuse	64.89	0.11	0.81	0.78	0.15	0.10	0.53
	7.30	0.03	1.62	5.26	0.40	3.38	2.48
Cotton ginning waste	6.95	1.56	0.68	1.37	0.24	0.27	0.05
Cocoa hull powder	11.09	2.71	1.49	2.94	1.04	0.51	1.39
Wool combing waste	4.95	0.68	0.29	4.40	0.12	2.41	1.87
	$H^2 O$	Ca O	Mg O	N tot.	$S O^3$	$C O^2$	Mat. in.
Lime residues from manufacture of lactic acid	46.00	19.23	0.44	0.30	27.50	0.97	0.68
Lime residues from bleaching factories	16.86	42.43	1.30	—	—	34.00	—
Lime residues from tanneries. . .	35.93	24.80	3.10	0.42	—	4.44	16.37

IV. — ALCOHOL, OILS AND OTHER INDUSTRIAL PRODUCTS OBTAINED FROM VARIOUS RESIDUES.

Products intended for food are not, speaking generally, included under this head: it seemed however desirable to deal here with certain edible oils: and for that reason the reader was referred to this part in the course of the earlier discussion of waste materials and residues utilised for human food.

The task at this point is therefore quite definite: it is confined to a description of certain utilisations for industrial purposes recommended during the war as necessary in view of the growing scarcity of products and the perpetual rise in their price. Some of these processes are not novel: sometimes processes that had fallen out of use were re-instated: sometimes improvements were introduced into methods that had been given up before the war. Very probably several of the processes here described are not adapted to modern economic conditions and are therefore impracticable. But if this brief account succeeds in being of interest to the reader and is a contribution to the information available as to utilisation of the various residues and waste materials, it will have attained its object.

1. — Alcohol from seaweed.

Certain seaweeds contain carbo-hydrates convertible into sugar by acids. By subjecting them to the action of sulphuric acid (3-6 %) under pressure for 30 to 50 minutes at 122° C. KAYSER (1) obtained ready fermentation and a yield of 12 litres of alcohol per 100 kg. of dry seaweed of the species *Laminaria digitata. L. flexicaulis* and *L. saccharina* were also tried.

The industrial process is as follows:— the seaweeds are dried artificially as soon as possible after they have been gathered, they are then chopped up and treated in an autoclave, at 120-125°C., with water acidulated with sulphuric acid. The excess of acid is next almost completely neutralized with potash, leaving an acidity of 0.7 to 1 % and the liquid is subjected to fermentation, after adding about 2 % of barley sprouts so as to furnish a little organic nitrogen which increases the yield.

C. KAYSER thus obtained 14.6 litres of alcohol per 100 kg. of dry seaweed. The residue, again treated in an autoclave, gave a further 7.53 % of alcohol.

(1) Cf. *Comptes rendus de l'Académie d'Agriculture de France*, Vol. 4, No. 14. Paris, 1918.

This process evidently depends on very cheap and easily obtained raw material; the principal expenditure is on labour and fuel, so that the process is worth considering in places where sugar yielding sea-weeds can easily be collected in large quantities.

Certain lichens (*Lichen islandicus* and *Cladonia rangiferina*) are of value on account of their high percentage of carbohydrates (lichenina) which varies respectively from 60 to 55 %. In this case too the treatment required is with 2.5 % of hydrochloric acid or with 6 % of sulphuric acid. The dextrose obtained is 60 to 66 % of the material analysed.

According to Ellrodt and Kunz in order to obtain the maximum yield of alcohol a treatment for one hour with steam (with a pressure equal to three atmospheres) is necessary, then one with hydrochloric acid for another hour with heating at the same pressure. By this method 1 kg. of lichen gives 282 cc. of alcohol, equivalent to 28.2 litres per quintal (0.1 metric ton).

It has been proposed to manufacture alcohol in this way from the lichens found in great abundance in Sweden, but it remains to establish in this case too the relation between the yield and the expenses of gathering and cost of the process (1).

2. — Alcohol from sawdust and peat.

Studies and experiments in the utilisation of sawdust for making alcohol has been made at various times.

Such researches were naturally pursued with redoubled vigour during the war, all the more so because some processes seemed to promise sufficiently high yields to render profitable the utilisation of large quantities of sawdust produced in the saw-mills and, in case of need, also of wood purposely reduced to meal.

It seems however probable that when the conditions of production of alcohol from mangolds, molasses, cereals and potatoes have again become normal there will not be much advantage in treating sawdust.

The general process of transforming sawdust into alcohol is as follows :— cellulose can be partly transformed into dextrose and other sugars by treatment with acids under pressure. After neutralisation of the acids with lime, soda, etc., the greater part of the sugar formed can be subjected to the action of an alcoholic ferment; the alcohol formed is then distilled (2). The procedure is as follows (3) :— the cellulose is hydrolysed with sulphuric, or hydrochloric, or sulphurous

(1) Monier Williams G. W. *Power-Alcohol.* London, H. Frowde and Hodder and Stoughton, 1922, p. 113.

(2) Cf. Simmonds Ch., *Alcohol*, p. 24. London, Macmillan.

(3) Formenti, op. cit., p. 263. — For the description of the processes in which the above acids are employed, see : 1) E. Hubbard, The Utilisation of Wood-Waste. London, Scott, Greenwood and Son, 1920, p. 135. In this work several processes of utilisation of sawdust are also discussed. — 2) Monier Williams G. W., op. cit., p. 129. — Cf. also : F. W. Kressmann, The manufacture of ethyl alcohol from wood waste, in *U. S. Dept. Agr. Bull.* 983. (1922).

acid, to transform it into dextrose, soaking it with ⅓ of acid (sulphuric) about 3 % strength while it is heated and stirred until a temperature of 165° C is reached for two hours. One ton of sawdust may yield from 200 to 250 kg. of sugar of which 85 % is capable of fermentation. The sugar is extracted by lixiviation with water, the liquid is neutralised with carbonate of lime, allowed to settle, decanted, and fermented with brewers' yeast; the alcohol is then distilled. From 100 kg. of sawdust, 6 litres of alcohol can be obtained, on the average, but certain writers indicate a yield which may be as much as 9 litres.

In MEISELS' process, which differs from the ordinary processes, the sawdust is treated in an autoclave (20 to 25 atmospheres) with a solution of caustic soda. The liquid obtained is next diluted, then sterilised with ozonized air and Mucedineae (*Amylomyces Rouxii*, *A. Oryzae*, etc.) are sown in it, which transform the cellulose into sugar; the latter ferments quickly without the addition of other yeast, and produces alcohol.

From 100 kg. of wood 42 kg. of sugar may be obtained and 65 kg. from 100 kg. of straw.

These figures seem to us exaggerated. There is also a KOCHER patent (English patent N. 107219), by which an almost complete conversion into sugar of the cellulose is obtained (in what manner is not stated) in 24-48 hours (1).

Peat (mossy peat containing 8 to 33 % of cellulose) is treated like sawdust. From 100 kg., 10 litres of alcohol is obtained. The residue can be used as fuel or as manure (2).

It is understood that the above figures apply to dry peat, since if the moisture is reckoned as 90 %, the yield of alcohol is only 1 %.

(1) Cf. *The South African Journal of Industry*, v. IV, No. 2. Pretoria, 1921. — For the preparation of wood meal, Cf. KRESSMANN Fr. W., in *The Scientific American, Supplement*, vol. LXXXII, No. 2127. New York, 1916.

In a paper by M. R. C. HAWLEY on the manufacture of alcohol from the waste wood which is obtainable in the United States forests it is stated that more than 134 million cubic m. are lost as waste in the forests and sawmills. Adding to that quantity 48.4 million cubic m. destroyed annually by fires, insects and fungi we get 182.8 million cubic m. which might be used for the production of liquid fuel. Allowing that 1 cubic. m. of wood weighs 480 kg. and that 1 ton will produce 62.5 litres of alcohol, the 182.8 million cubic m. equivalent to 87 744 000 t. could furnish 54.8 million hectolitres of alcohol.

By calculating also the increased production which would result from intensive forestry the writer reaches double the above mentioned quantity of alcohol.

With present methods of manufacture of wood alcohol, the cost of wood at the factory is estimated, on the average, at 25 *cents* per gallon (0.34 fr. per litre of alcohol produced) but this cost could be reduced to 7 *cents* per gallon (0.09 fr. per litre).

But after that, there is one very important observation to be made, mainely that further improvements are necessary in the processes of utilisation of the cellulose so as to obtain an increased yield of alcohol. In any case — the writer remarks — this utilisation of wood on a large scale for the manufacture of alcohol cannot become very important in the United States for the next ten years or more (Cf. *The Journal of Ind. and Engin. Chem.*, V. 13, No. 11, N. Y., 1921, p. 1059).

(2) *Bulletin de l'Assoc. des Chim. des Sucr. et Distill.*, 1907, No. 24.

By the PIQUE process (1) 225 kg. of moist peat are treated with 400 to 460 litres of water and 3 to 4 litres of sulphuric acid for 45 minutes under a pressure equivalent to three atmospheres. The liquid separated under this pressure is made to ferment by adding an alcoholic ferment (*Saccharomyces ellipsoideus*) which has previously become used to the action of the toxic substances in the peat.

In conclusion the repeated attempts by various processes to extract alcohol from substances containing cellulose have generally given unsatisfactory results, so that, now as formerly, we may consider this problem as far from solution.

3. — Alcohol from straw.

On this subject some memoranda are available (2) of a lecture recently given by Dr. HARGREAVES, Director of the Division of Chemistry of the South Australian Industrial Department. He states that if the straw grown round Adelaide within a radius of 100 miles (more than ½ million tons) was used in making alcohol, instead of being neglected or wasted as at present, 80 gallons of alcohol per ton of straw, or a total of 40 million gallons could be obtained, which could be used for internal combustion motors.

The periodical quoted points out that the writer has not given detailed information regarding the process which he recommends. But there seems reason to think that this process is one of those by which sawdust is treated by hydrolysis with a dilute mineral acid under pressure, to transform the existing starch and part of the cellulose into sugar capable of being fermented.

Experiments on a commercial scale were carried out in Burma with rice straw, on the lines of the process patented in England by A. B. C. ROGERS and C. H. BEDFORD (No. of patent 144,079, 1919): the straw was first treated with superheated steam, then converted into pulp and digested with hydrochloric acid (3). The liquid obtained is neutralised and then fermented. The exact figures of the yield in alcohol are not available, nor is it clear whether the sugar obtained is the result of hydrolysis of the cellulose or derived from the preformed sugars or the hexosans of the straw, as seems probable.

In rice straw, TAKEUCHI of Tokio found the following percentages: dextrose and sucrose 3.5, starch and hemicellulose substances 15, pentosans 15, protein, fats etc. 7, crude fibre 31, ash 12.

4. — Alcohol from maize rachides (4).

W. H. PETERSEN, E. B. ZRED and J. H. VERHULST made experiments in the fermentation, using *Bacillus acetoethylicum*, of a syrup obtained by hydrolysis with dilute sulphuric acid from maize stalks:

(1) JACQUET L., *L'Alcool*, p. 42. Paris, 1912. Masson & Cie.
(2) *Commercial Fertiliser*, vol. XXIII. No. 6. Atlanta, G. A., 1921, p. 40.
(3) Cf. MONIER WILLIAMS G. W. Op. cit., p. 147.
(4) Cf. *Journal of Indust. and Engin. Chem.*, Vol. 13. No. 9. Washington, 1921.

their results were, for every 100 parts of weight, 6.8 of ethyl alcohol, 2.7 acetone, 3.4 volatile acids. In addition formic acid, acetic acid, and carbon dioxide result.

By heating the stalks for about an hour in a pressure of 1.35 atmospheres with dilute acid (*i. e.* water four times, and acid eight times the weight of the stalks), there is obtained a higher yield of fermentable sugar, *i. e.* 25 to 30 %, chiefly xylose.

5. — Alcohol from liquid residues of cellulose manufacture.

For every ton of cellulose produced there are about 10 tons of these liquid residues, which contain dextrose and other sugars, various acids, methyl alcohol, nitrogenous matter and resinous substances.

The quantity of sugars susceptible of fermentation is between 1.5 and 2 %.

To effect fermentation of these liquid residues it is first of all necessary to eliminate from them, by evaporation, the sulphurous acid which would kill the ferments. Extract of malt is added and the ferment sown. After a few days fermentation is finished and the liquid is distilled in apparatus working without interruption. The alcohol obtained is slightly impure since it contains a little methyl alcohol, some aldehydes and some furfurol.

The yield in alcohol is 1 % or more of the evaporated liquid residue (1).

In Germany these liquid residues were largely used during the war. Twelve factories were established capable of dealing with the liquid derived from the production of 287,000 tons of dry cellulose. About 3.2 % of alcohol was obtained mainly used for the manufacture of explosives. According to BERGSTROM 10 kg. of methyl alcohol, used in the manufacture of varnish and various chemical products, can be obtained per ton of dry cellulose.

According to G. J. FOWLER and B. BANNERJEE (2) motor-spirit can be obtained from the residual sugar of cane-trash and the sugar yielding substances it contains, and also from the residues of the cellulose pulp used for paper-making. The hydrolysis is effected in an autoclave lined with lead, by the use of sulphuric acid diluted from 0.35 to 0.50 % in quantities not exceeding 6 % of the weight of the fibre. The best result is obtained after 15 to 30 minutes with a pressure not higher than 4.5 kg. per cc.

The heating and subsequent cooling have to be very rapidly effected, so as to counteract the destructive action of the acid on the fibre. The highest percentage of sugar thus produced was 36 % when the cane-trash contained 7 %. Allowing for a 1 % loss of the orig-

(1) Cf. 1) SIMMONDS Ch., *Alcohol*, 0. 97. — 2) MONIER WILLIAMS G. W. op. cit., p. 148.

(2) Cf. *Journ. Indian Int. Sci.*, No. 15, 1921.

inal sugar it may be estimated that with hydrolysis of the non-fibrous tissue 30 % of sugar was obtained.

The saccharine solution is clarified with lime and fermentation is induced. The net yield of alcohol, apart from that obtained from the original sugar contents of the residue, is about 8 to 9 %.

From "acque d'inferno" (1) which are produced in hundreds of thousands of tons in olive-growing countries, there can be obtained, by speedy fermentation, about 15 litres of rectified ethyl alcohol per ton, as well as from the distillation residue, 3 kg. of ammonium sulphate, and 3 kg. of phosphoric acid, or of potassic salts. The partly solid residue after these extractions can be distilled and gas and carbon obtained. It is worth noting that this is only advantageous when large quantities of this water is available.

6. — Alcohol from horse-chestnuts.

During the war large quantities of horse-chestnuts were utilised by the distilleries for making alcohol and acetone intended mainly for manufacture of explosives; and corresponding quantities of maize, barley, potatoes and molasses were thus saved.

The crushed horse-chestnuts are converted into sugar either with acids or with malt, brewer's yeast is then added and it is made to ferment.

A good starch may also be extracted from them by the ordinary processes of lixiviation of flour. They are also used for making tan extracts.

Researches made by KAYSER, Director of the Laboratory of Zymotechnics of the Agricultural Institute at Paris (2), have shown a yield of 27-28 litres of alcohol per 100 kg. of dry horse-chestnuts. This yield is less than that obtained with maize but it is profitable because of the low cost of the raw material.

7. — Alcohol from acorns.

The treatment of acorns, from various species of oaks, containing about 40 % of starch and a little saccharose, is similar to that described for horse-chestnuts. KAYSER (3) by saccharifying the starch in them in an autoclave at 120-122° C. with water acidulated with 2.5 % of hydrochloric acid + 1 % of sulphuric acid, for one hour, obtained a yield of 8.58 to 20.16 litres of alcohol per 100 kg. of whole dry acorns, and of 28.3 to 31 litres per 100 kg. of seeds without cupules.

(1) R. DE MANJARRÈS. *Rev. Vin. y de Agr.*, XLI, No. 4 Saragossa, 1922.

(2) *Feuille d'Informations du Ministère de l'Agriculture*, Year XXII, No. 45. Paris, 1917.

(3) Cf.: 1) *Feuille d'Informations du Ministère de l'Agriculture*, Year XXII, No. 5. Paris, 1917. — 2) *The South African Journal of India*, vol. IV, No. 2. Pretoria, 1921. — 3) *The Indian Forester*, vol. 48, No. 3. Allahabad, 1921.

8. — Alcohol from certain arums.

Alcohol is derived from two species of the Aroideæ, *Arum maculatum* L. and *A. italicum* L. (Fig. 80), which grow wild along hedges and in woods of Northern Italy and of the Apennines, in the sub-alpine and mountainous regions. They also grow in other temperate climates under similar conditions. These plants have a feculent rhizome, larger in the second species, which may attain at 3 years old a maximum weight of 250 gm. and an average weight of 80 gm.

FIG. 80. — *Arum italicum*. Leaves, Spadix and Fruit.

From BRUTTINI A., op. cit.

If these plants, which are regarded as weeds, are gathered in the non-growing season they give rhizomes fairly rich in starch.

Prof. E. PANTANELLI (1), Director of the "Station d'Aridoculture" at Bari, has obtained under these conditions, from fresh rhizomes, 18 % of pure starch, 20 to 23 % of glucose and by fermentation of the latter 10 % of alcohol, all of good quality.

M. PANTANELLI states that the arum can be cultivated but that it is better to use the wild arum.

9. — Alcohol from asphodels.

The plants used are two of the Liliaceæ, *Asphodelus ramosus* L., the more common (Fig. 81-82), and *A. luteus* L. both herbaceous, perennial plants, with tuberous roots, edible. They grow spontaneously in large numbers on uncultivated land in rather warm climates: — Sicily, Southern Italy, Southern Europe, North Africa, Asia Minor, etc.

In Arabia an excellent gum is extracted from the roots. Both roots, and when fodder is scarce, also the leaves are fed to cattle, goats, donkeys and pigs. Cooked and dressed in different ways these roots are also used as human food.

Their utilisation for the manufacture of alcohol is fairly ancient. It has been recently tried by Prof. E. PANTANELLI (2) and by E. MONACO (3).

(1) *Le Stazioni sperimentali agrarie italiane*, vol. 41, Parts 1-2. Modena, 1918.
(2) Cf. *Le Stazioni sperimentali agrarie italiane*, vol. 41, Parts 3-6. Modena, 1918.
(3) Cf. *Ann. d'Ing. e Arch.*, Year XXXIII, No. 8. Rome, 1918.

The sugar and the colloidal carbo-hydrates susceptible of being converted into sugar contained in the roots give a yield of 14 % of alcohol if they are collected in December and of 22 % if collected in August. The best season for collecting is the flowering season, in May-June.

From 100 kg. of roots 8 kg. of alcohol can be obtained, but, in practice, 6 to 7 % is not exceeded.

If cultivated the asphodel might produce 8 tons of roots per acre. For manufacture of alcohol, they are subjected to the following operations:— washing, chopping, pressing, addition of 25 % of lukewarm water to the residue and a second pressing; addition of sulphuric acid at 2-3 % strength and boiling; fermentation with brewer's yeast (200 gm. per 120 litres of liquid); distillation.

Fig. 81. — *Asphodelus ramosus*. Inflorescence and tubercles.

From Bruttini A., op. cit.

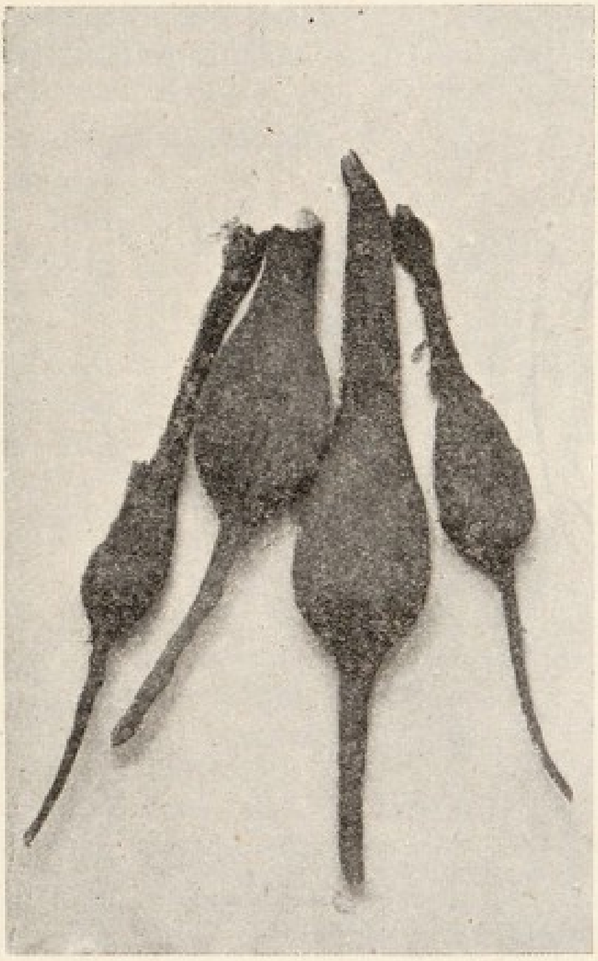


Fig. 82. — Tubercles of (two years' growth) of *Asphodelus ramosus*, gathered at *Maccarese*, Rome.

From the barked green stalks of *A. ramosus* textile fibre may be derived by retting; it can also be obtained from the leaves which are gathered for this purpose when growth is most active, that is to say at the flowering season (1). The best roots for collection are those of the 2nd year. They contain a bundle of strong fibres which can be used as textile material, provided the roots are crushed without rasping or cutting them. These fibres are of two kinds — those which are

(1) Cf. Mingioli E., Dell'utilizzazione dell'*Asphodelus ramosus*. *Boll. quindicinale della Soc. degli Agric. Ital.*, Year XIV, No. 5. Rome, 1909.

near the bark have a silky-fibrous texture; those inside are cottony and are more suitable for making a paper pulp of good cohesive quality. The turions and roots are, as has been stated, eaten by animals and sometimes by man, but are especially suitable for pigs after the bitter substance is removed by soaking in water followed by boiling.

10. — Alcohol from feather hyacinths.

Muscari comosum (Fig. 83) and *Hyacinthus ciliatus* were the subject of experiments made by Prof. E. PANTANELLI (1) with a view to the production of alcohol, and to their use for human consumption.

FIG. 83. — Feather hyacinth. (*Muscari comosum*). Inflorescence, Flower, Leaves and Bulb.

From Dr. A. FIORI, op. cit.

In the country parts of the Province of Foggia the bulbs of these two species are eaten by the country folk and those of the former are even exported to America for the use of the emigrants from Foggia who are living there.

The experiments showed that the bulbs contained, respectively, 23.01 and 20.21 % of sugars + carbo-hydrates susceptible of conversion into sugar, determined at the end of the growing period Hydrolysis was effected by boiling the bulbs for an hour and a half with an equal weight of sulphuric acid of 4 % strength. The excess of acid was then neutralised with carbonate of lime, the liquid expressed and 1 % of phosphate of ammonium added, then tartaric acid until the precipitate of phosphate of lime was dissolved. Distiller's yeast was next added and the whole allowed to ferment at 20° C. for 4 days. The experimenter obtained absolute alcohol 10.5 % in weight and 13 % in volume of the bulbs with *Muscari comosum* and 8.4 and 10.5 % respectively with *Hyacinthus ciliatus*.

These yields show that the manufacture of this alcohol would be profitable. The best season for harvesting these spontaneous bulbs, in Apulia, is from June to December.

The bulbs should be used fresh; otherwise their yield of alcohol decreases.

(1) Cf. PANTANELLI E., Uso del cipollaccio per l'alimentazione umana, e la produzione dell'alcool, in *Le Stazioni sperimentali agrarie italiane*, vol. LIII, Nos. 1-3. Modena, 1920.

11. — Alcohol from wild chervil.

Wild chervil (*Anthriscus sylvestris*) (Fig. 84) is a biennial umbellifer very abundant on wooded lands (1). The fresh root contains:— reducing sugar 0.96 % — saccharose 5.64 % — fecula 14.50 %. Stock refuse to eat it on account of its disagreeable odour.

To obtain alcohol from it, the sugars might be extracted with water and the remaining starch would be treated by the ordinary processes. The collection of the roots should be made after the 1st year of growth.

12. — Alcohol from prickly pears.

As the different kinds of prickly pear, and especially the *Opuntia ficus indica*, cultivated in Sicily and elsewhere, yield large quantities of fruit, more or less saccharine, it would be a great advantage to be able to utilise them for making alcohol. Attempts on a more or less extensive scale have been made from time to time, but the results have not been encouraging either in quality or quantity. According to C. Ulpiani and L. Sarcoli (2) a selected ferment should be used, the mixture having first been sterilised, but this is not a suitable process from the economic standpoint. When *Saccharmyces Pastorianus II* was added to the mixture, the percentage by weight of alcohol resulting was 8.21, while by using the ferment occurring on the plant (*Saccharomyces Opuntiae*) the percentage was 5.62.

Prof. Pantanelli (3), by causing these fruits to ferment through the medium of metabisulphite of potassium (30 gm. per 100 kg.), obtained 9 litres of absolute alcohol per 100 kg. of fruit, i. e. at least 600 litres per 1 hectare (2.47 acres), and in addition 900 kg. of dry residues from the pressing process (which contained 64 kg. of oil, 5 kg. of phosphoric anhydride, and 97 kg. of potash and soda), and also 450 kg. of dry distillation residue which can be used as stock-feed or fertiliser (4).

(1) Cf. Colin H., in *Bulletin de l'Association des Chimistes de Sucrerie et de Distillerie*, Vol. XXXV, No. 10-12. Paris, 1918.

(2) Cf. *Gazzetta Chim. Ital.*, Vol. XXXI, part. II, Rome 1906.

(3) E. Pantanelli. Produzione di alcool dal fico d'India, in *Le Staz. Sperim. Agr. Ital.*, Vol. LIII. Modena, 1920.

(4) A Company has been formed at Bloemfontein with a capital of £100,000 under the name of the "South African Motor Fuel Development Co. Ltd." for the manufacture of alcohol as fuel from the prickly pears which grow wild there over a territory of 2 million acres. Reckoning the production of fruit as 20 tons per *morgen* (about two acres), and that every ton of pears may produce 13 gallons of alcohol, the two million acres should yield 260,000,000 gallons. (Cf. *South African Journal of Industries*, Nov. 1922).

13. — Alcohol from arbutus (1).

The fruits of this woodland plant (*Arbutus Unedo*, L.) (fig. 85), widely spread in Italy, Spain, Dalmatia, etc., contain considerable quantities of sugar, but it has not proved of economic advantage to extract it. It is however easy to obtain a liqueur of excellent quality by fermenting the fruits. According to Prof. La Marca the alcohol rectified to 80° C is almost equal to that of wine and better than that of wine-lees. La Marca adds however that care must be exercised in the fermentation and also in gathering, which must be systematically carried out under good weather conditions.

An Arbutus wine is also made containing about 9 % of alcohol, called in Tuscany " Albatrino " (from the name " Albatrella " given to the fruit). The yield in alcohol, according to an experiment of S. Loddo of Lannusei, would be about 6.70 litres at 70° to 72° per hectolitre of fruit of the first gathering in November. This alcohol is suitable also for liqueur making.

During the war the following species were also recommended for the production of alcohol (2) : — *Berberis vulgaris* (fruit) (fig. 86) ; *Vaccinium Myrtillus* (fruit) ; *Empetrum nigrum* (fruit) ; *Daucus Carota*, wild (roots) ; *Heracleum sphondylium* (roots) ; *Lathyrus montanus* (tubers) ; *Triticum repens* ; *Phragmites communis* (roots) ; *Ceratonia siliqua*, carob (fig. 87) (fruit) (3), etc.

14. — Oils from plant residues.

In the following chapters information has been brought together as to the characteristics and uses of various oils edible or non edible obtained from plant residues. In the section dealing with human food prepared from various residues it was noted that the question of oils would be dealt with in this part.

But before discussing separately the chief kinds of these oils, it seems advisable to subjoin, as a general survey, a list of wild plants, from which are extracted or might be extracted oils and other fats.

(1) Cf. 1) G. Sani, *Atti R. Accad. Lincei*, 1913, Vol. XXII, fol. 12, 1st series, p. 884. — 2) La Marca F. *Il Corbezzolo*, Casale, Marescalchi, 1914, with bibliography.

(2) Diels, op. cit., p. 218.

(3) In the manufacture of *alcohol from carobs* about 10 per cent. of seeds are obtained as waste with mechanical separation ; these seeds are purchased by factories of coffee substitute in Italy and elsewhere at about 2 *lire* per kg. (present price) ; that is to say this waste material decreases the cost of carobs by 20 *lire* per 100 kg. In a carob distillery at Catana (Sicily), tannin is also extracted from this waste, while burning the residue from the used up carobs effects a considerable economy of coal for the boilers : 100 litres of absolute alcohol = 30 kg. of coal. (Cf. *Giorn. di Chim. Ind. e Appl.*, Years III-V, Nos. 12-13, Milan, 1921, 1923.

A complete list would be too long and too difficult to compile; this one merely contains the commonest and most accessible species of both the European and colonial flora.

FIG. 84. — Wild chervil. Flowers, Leaves and Fruits.

From Dr. A. FIORI, op. cit.

FIG. 85. — Arbutus. Flowers, Leaves and Fruits.

From Dr. A. FIORI, op. cit.

FIG. 86. — *Berberis vulgaris*. Flowers, Leaves and Fruits.

From Dr. A. FIORI, op. cit.

FIG. 87. — Carob. Flower, Leaves and Pod.

From BRUTTINI A., op. cit.

PLANTS YIELDING OILS AND OTHER FATS, EDIBLE, INDUSTRIAL, MEDICINAL, ETC. WHETHER FROM FRUITS, SEED, ETC. (1).

Drying oils: *Cirsium* sp. — *Carduus* sp. — *Lappa* sp. — *Carya olivaeformis*, *C. alba* — *Nicotiana Tabacum*, *N. rustica* — *Hyoscyamus nigra* — *Atropa Belladonna* — *Solanum Lycopersicum* — *Picea excelsa* — *Pinus sylvestris*, *P. Cembra* — *Asparagus officinalis* — *Robinia Pseudacacia*.

Semi-drying oils: *Cucurbita Pepo* — *Fagus sylvatica* — *Brassica* sp. — *Sinapis* sp. — *Raphanus sativus*, *R. Raphanistrum* — *Lepidium sativum*.

Non-drying oils: *Pyrus* sp. — *Prunus* sp. — *Ulmus* sp. *Evonymus europaea* — *Citrus* sp. — *Corylus Avellana* — *Cornus sanguinea* — *Ligustrum vulgare* — *Sambucus racemosa*, *S. nigra* — *Aesculus Hippocastanum* — *Tilia* sp. — *Vitis vinifera* — *Ribes* sp. — *Rubus* sp. — *Berberis vulgaris* — *Cydonia japonica* — *Rosa* sp. — *Fragaria vesca* — etc.

The following species may also be mentioned, taken from works by E. Chiovenda, Y. Henry and H. Jumelle:

Cyperus longus L., *C. esculentus* L. — *Cimbopogon nervatus* Chiov., *C. giganteus* Chiov., *C. comatus* Chiov., *C. sennaarensis* Chiov. — *Ximenia americana* L. — *Argemone mexicana* L. — *Moringa oleifera* Lam. — *Citrus Hystrix* D. C. subsp. *acida* Proxb. — *Balanites aegyptiaca* Del., *B. Manganii* Spr. — *Trichilia emetica* Vahl. — *Melia Azedarach* L. — *Azadirachta indica* Juss. — *Jatropha Curcas* L. — *Ricinus communis* L. — *Thespesia populnea* Car. — *Calophyllum Inophyllum* L. — *Polygala butyracea* Heck. — *Securidaca longipedunculata* Fres. — *Carum copticum* Benth. — *Butyrospermum Parkii* Kot. — *Salvia nudicaulis* Vahl., *S. Schimperi* Benth. — *Hyptis spicigera* Lam. — *Telfairia pedata* Hook. — *Guizotia abyssinica* L. — *Adansonia digitata* — *A. madagascariensis*, *A. Grandidieri* — *Pentadesma butyracea* etc. — *Lophira alata* — *Carapa guineensis* — *Irvingia gabonensis*, *I. Olivieri* — *Pentaclethra macrophylla* — *Garcinia indica* — *Lecythis urnigera*, *L. Ollaria* — *Acrocomia sclerocarpa* — *Attalea Cohune* — *Juniperus macrocarpa* — *Pistacia Lentiscus*, *P. Terebinthus* — etc. (2) (3).

15. — Oils from seed residues of wild plants, etc.

Besides those mentioned there are many other oils that can be obtained from seed residues or from seeds and fruits of wild plants, ordinarily not utilised. The list of these plants would be very long,

(1) Cf. Diels, op. cit.

(2) Cf. Grieve M. Economic Tree and their By-products. Pr. by F. Newbery, London, 1920.

(3) For many oils obtained from Italian or exotic plants, not mentioned here, see, besides Lewkovitch, already frequently quoted, also H. Jumelle, Les Huiles Végétales. J. B. Baillière et fils, Paris, 1921.

here only the principal characteristics of the best known kinds of oils will be noted (1).

*Oils of apple and pear pips.**

	Apple pip (20 %)	Pear pip (20 to 28 %)
Specific weight	0.9016	0.9177
Acidity	57.4	39
Hehner No.	93	91
Köttstorfer No	202.00	113
Iodine No	135	121
Fatty acids : Iodine No.	83 to 85	101 to 104
» » Saponification No.	288	196

*Oil of seed of wild artichoke** (15 to 18 %).

Oil of charlock seed (*Raphanus raphanistrum*) (30 to 40 %). Specific gravity at 15° C. 0.917.

*Oil of Kapok seed** (*Eriodendron anfractuosum*) (20 to 24 %). Extracted under pressure: Specific weight at 15° C. 0.9218; refractive index at 40° C. 1.4630; iodine No. 88.7; acidity 21.6; saponification No. 192.3; Reichert-Meissel No. 0.8; Polenske No. 0.14 to 0.34.

*Oil of lime tree seeds** (*Tilia* sp.) (up to 58 %). A yellowish oil of palatable flavour; at 20° C. is still fluid, keeps well and if kept covered from the air will not become rancid.

Oil of Kaki seed (*Diospyros virginiana*). Colour brownish yellow. A semi-drying oil. Specific weight at 15° C. 0.9244; freezing point —11° C.; melting point —6° C.; saponification No. 188; iodine No. 115.6; Reichert-Meissel No. 0.0; Hehner No. 95.9; acetile No. 7.15.

*Oil of the seeds of Evonymus ** (*Evonymus Europaeus*) (28-29 %). Reddish-brown in colour. Specific weight at 15° C. 0.9390; saponification No. 230.1; iodine No. 100; ethers index 146.1; Reichert-Meissel No. 35.1; Hehner No. 83; glycerin No. 7.99 %; refractive index at 40° C., 52; freezing point, — 10° C.

*Spurry seed oil ** (*Spergula arvensis*) (11.2 %). Saponification No. 181; acidity 13.7; iodine No. 146.2.

*Oil of elm tree seed ** (*Ulmus campestris*) (26.9 %). Extracted with benzene and has a greenish colour, without any particular smell or taste. Specifie weight at 20° C.; 0.9559; freezing point —3.5° C.; melting point + 5.7° C, acidity 5.57; saponification No. 277.3; Hehner No. 75.45; Reichert-Me'ssel No. 3.75; iodine No. 32.2.

Oil of Chili seed (*Capsicum annuum*) (20 %). Specific weight at 15° C. 0.9296; acidity 52; Hehner No. 92; Köttstorfer No. 270; iodine No. 84.5; refractive index 1.4776.

(1) The particulars are taken from the work of L. E. ANDES Vegetabilische Fette und Oele. Vienna and Leipzig, A. Hartleben 1921, pp. 176 and seqq. — See also J. LEWKOVITCH, op. cit. — JUMELLE H. Les Huiles végétales. Paris, Baillière, 1921. — JAMIESON, G. S. and BAUGHMAN W., Okra Seed Oil, in *Journ. of the Amer. Chem. Soc.*, Vol. XLII, No. 1, 1920. — * Oils marked with an asterisk are not drying oils; those without asterisk are drying oils.

Oil of bilberry seed (*Vaccinium myrtillus*) (31. %). Specified weight at 15° C. 0.9331 ; refractive index at 40° C. 71.8 ; iodine No. 167.2 ; saponification No. 190.4 ; acidity 6.8 ; Reichert-Meissel No. 0.66, Polenske No. 0.30.

Oil of pineseed (*Pinus sylvestris*) (about 32 %). Specific weight at 15° C. 0.9326 ; saponification No. 189.8 ; iodine No. 147.1 ; refractive index, at 40° C 1.4685 ; acidity 0.8.

Oil of buckthom seed (*Rhamnus cathartica*) (8.85 %). Greenish-brown in colour, scentless, but with a pleasant taste.

Oil of spruce seed (*Pinus abies* L.) (21.8 %). Yellow, thick with a pleasant scent. Specific weight at 15° C. 0.9326 ; saponification No. 192.6 ; iodine No. 120.9 ; refractive index at 40° C 1.4685 ; acidity 4.2 ; fatty acids 91.52 % (see p. 341).

Oil of cedar seed (*Pinus cembra*) (56 %). Specific weight at 15° C. 0.930 ; Hehner No. 91.97 ; saponification No. 191.8 ; iodine No. 159.8 ; acidity 3.25 ; glycerin 10.31 % ; fatty acids 95.74 %.

Oil of dwarf mountain pine seed (*Pinus montana* Möll.) (29.6 %). Specific weight at 15° C. 0.9318 ; saponification No. 189.6 ; iodine No. 1.457 ; refractive index at 40° C. 1.4680 ; fatty acids 91.3 %.

Oil of cypress seed (*Cupressus sempervirens*). Green, with aromatic scent and taste. Specific weight at 15° C 0.9320 ; saponification No. 188.6 ; iodine No. 135.1 ; refractive index at 40° C. 1.4829 ; acidity 2.3 ; fatty acids 91.58 %.

Oil of asparagus seed (*Asparagus officinalis*) (15.3 %). Yellowish red. Specific weight at 15° C 0.928 ; No. of saponification 194 ; iodine No. 137.

Oil of okra seed (*Abelmoschus esculentus*). Iodine No. 93.2-100.3 ; saponif. No. 195.5 ; Polenske No. 0.23 ; Reichert-Meissl No. 0.26 ; acetyl value 11.5-23.9 ; acid value 0.34-1.42 ; refractive index at 25° 1.47 ; non-saponif. matter % 0.37 ; non-saturated acids % 67.33 ; saturated acids % 29.22.

Other oils obtained from wild plants are as follows :

Burdock oil (*Lappa communis*) ; Ritro Globe thistle oil (*Echinops Ritro*) ; Cow-wheat or Horse flower oil (*Melampyrum arvense*) ; Dwarf elder oil (*Sambucus racemosa*) ; Bastard rocket or Bazocks or Wild Mustard oil (*Brassica arvensis*) ; Caper spurge or Euphorbia oil plant (*Euphorbia Lathyris*) ; Iy-chee oil (*E. dracunculus*), etc.

16. – Oil of maize.

In starch and glucose factories and in the distilleries using maize, this oil is extracted from maize germs. As immense quantities of maize are used, very large quantities are obtained, especially in the United States and in Argentina, of germs and of oil, extracted by hydraulic pressure.

The dry germs contain 53 % of oil, but in practice the yield does not exceed 40 %. In the whole grain the proportion of oil varies between 4 and 10 % (1). Maize germ cake is fed to cattle. Well prepared oil of maize is of a light yellow colour, but when albuminoids and fermented matter are present it becomes darker in colour and is not suitable for the manufacture of light coloured soaps. It is semi-siccative and lacks viscosity. It has a special odour and a taste at first pleasant resembling that of freshly ground maize. It contains a fairly large proportion of non-saponifiable matter (from 1.35 to 1.55 % or more) consisting of lecithin and phytosterol.

For purifying this oil a threefold process is in use in the United States *i. e.*: 1) neutralisation with caustic soda; 2) bleaching with kaolin (5 %); 3) vaporisation, at 225° C. (437° F.) for two hours in vacuo (2).

If a current of air at 150° C. is made to pass through this oil and manganese borate is added to it, it congeals to a viscous mass in about twenty hours. Refined oil of maize is edible (salad oil); it is much used for making oleomargarine, artificial lard (replacing cotton seed oil) and also soft soaps.

Its characteristics are as follows:— specific gravity at 15° C., 0.9215-0.9239 — freezing point, —10° to —15° C. — saponification index 188 to 193 mg. of KOH — iodine index, 111.2 to 130.8 — Reichert-Meissl index, 2.5-4.2-4.3 — refractive index at 15°.5 C., 1.4768 — Maumené's test, 79-89° C.

This oil is manufactured on a large scale in the United States and in Argentina. During the war this manufacture developed considerably in Hungary (3). In Belgium all the lubricants manufactured by the "Comité National de Secours et d'Alimentation" had oil of maize for basis.

It is scarcely suitable for greasing. To improve it, it was purified with acid and then tallow and mineral oil were added in the proportion of 55 %, 40 % and 5 % respectively. These proportions were varied.

Treating it chemically, the oil was purified with ammonia, and then thickened by means of peroxide of lead, insufflation of hot air and the addition of tallow, but in a smaller proportion than in the preceding process.

Lastly oil of maize was used for lighting in coal mining, for churches, for the manufacture of household soaps, for pharmacy, for greasing and in the latter stages of the war it was refined for feeding the population (4).

(1) Cf. Dr. J. Lewkovitch, Chemical Technology and Analysis of Oils, Fats, and Waxes, Vol. II. London, Macmillan, 1909, p. 128.

(2) Cf. A. F. Sievers: 1) Comparison of corn oils obtained by expeller and benzol extraction methods. — 2) The preparation of an edible oil from crude corn oil. *U. S. Dept. of Agric. Bull.* Nos. 1054 and 1010, Washington, March 1922 and April 1922.

(3) Cf. Weiser St., *Die Landw. Versuchs-Stationen*, Vol. CXVII. Berlin, 1920.

(4) Cf. Rapport Général sur le Fonctionnement et les Opérations du Comité National de Secours et d'Alimentation, Part II. Le Département d'Alimentation, vol. I. Brussels, Vromant et C., 1921, p. 92.

17. — Oil of rice (1).

By this is meant the oil extracted from the rice bran, generally called in Italy *pula vergine* (virgin husk), which is made from the outer integument of the seed, from the embryo and part of the cotyledons and from the aleuron layer, with an admixture of some broken seed and various residues.

This residue has already been discussed under feed for livestock (see p. 152): here some notes will be given as to the fats it contains.

The oil obtained from fresh husk is neutral or nearly so, but as time goes on free fatty acids develop rapidly owing to the presence of an enzyme, the action of which can be practically stopped by heating up to 100° C.

The extraction of this oil can be effected either by hydraulic pressure or by solvents: the oil resulting from pressure is liquid and a greenish yellow white in colour: that obtained by solvents — considerable quantities are so obtained in Louisiana, U. S. A., and in England — is deeply coloured, though fluid, with deposits of stearine. It is used in the manufacture of soap.

The cake resulting from the extraction under pressure contains 8 to 9 % fats, 2.7 to 2.8 % nitrogen, 17 to 18 % of crude protein, and is therefore an excellent feeding stuff. That obtained by solvents is almost destitute of fat, but keeps a long time and can be used as feed either as it is or treated with molasses. It may also be used for extraction of starch which is present in the proportion of 50 %, or for the resulting alcohol, 20 litres per 100 kg.

In an oil of rice obtained by extraction by means of petrol ether, Prof. F. GARELLI noted the following characteristics: at an ordinary temperature a white solid of a dirty yellowish tinge, melting point 25° to 26° C., acidity 90.9, saponification No. 186, ethers No. 95.1, glycerine 4.85, non-saponifiable substances 3.2 %, Hehner No. 95.2, iodine No. 99.7. Dr. MERCARELLI found by taking an average of five samples: index of acidity (milligr. of KHO) 136.1; acidity in oleic acid 68.33 %. Oil obtained by pressure has a density of 0.912, that got by solvents a density of 0.923.

18. — Olive kernel oil.

Olive kernels may yield, either by pressing or by means of solvents, from 25 to 28 % of oil. By pressing cold a golden yellow coloured oil is obtained, by pressing hot a greenish oil, and by means of solvents an oil rendered dark green owing to abundance of chloro-

(1) Cf.: 1) J. LEWKOVITCH, op. cit., Vol. II, p. 260. — 2) *Il Giornale di Risicoltura*, Year XI, No. 9. Vercelli, 1919. 3) INSTITUT COLONIAL DE MARSEILLE. Mémoires et Rapports sur les Matières Grasses, Vol. I. Marseille, 1922, p. 363.

phyll. Its taste is sweetish, similar to that of almonds. It contains about 10 % of fatty acids :— palmitic, stearic, oleic and a little linoleic acid. The oil obtained of late is almost entirely free from fatty acids. The cake is a good cattle food ; the shells are used for fuel.

The physico-chemical characteristics of this oil are as follows :— specific gravity (of oil obtained from fresh seeds), 0.9184 to 0.9191 (of oil from dry seeds), 0.9193 ; then, respectively :— saponification index 182.3 to 183.8 and 181.2 — iodine index 86.99 to 87.8 and 87.1 — refractive index at 25° C., 1.4682 to 1.4688, and 1.4673.

19. — Grape seed oil.

When dealing with grape residues and grape seeds as food for livestock mention was also made of the oil content of these seeds which are separated by means of special sieves from the residues, and especially from the distilled lees, to the extent of 12 to 15 % (1).

The grape-seed oil industry is of fairly ancient standing in Italy, existing at Bergamo in 1770, but its present development dates from the past 20 years (2). The grape seeds are generally supplied by the lees distilleries, either in the natural state (not distilled), or distilled and cooked. The former contain 12 to 20 % of oil, the latter 8 %. Those obtained from Venetia are richest in oil ; the percentage of oil depends on the vine, the age of the seed, etc. In the dry state, the grape seeds contain :— moisture 9-12 % — oil 12-20 % — carbo-hydrates 9-12 % — nitrogenous matter 10-11 % — mineral matter 2.5-4 %.

In Italy, the most important oil factories manufacturing grape seed oil are situated in Lombardy, Piedmont, Emilia and Apulia.

The method of extracting the oil consists first in reducing the seed to meal, which is moistened, heated in a special apparatus at 50-60° C. and subjected to hydraulic pressure of 250 atmospheres. The cake which remains is sometimes kneaded with water and subjected to further pressing, after which is it used either as fuel or as food for livestock. But instead of pressing, solvents (benzol, tetra-chloride of carbon, ethylene trichloride, carbon disulphide) (3) are also used.

As already stated attempts were made during the war outside Italy to utilise this cake for cattle food, but in Italy little or no such

(1) A quintal (100 kg.) of fresh grapes thus yields about 3,5 kg. of seeds.

(2) Cf. : 1) FACHINI S., dans *Giornale di Chimica industriale e applicata*, Year II, new series. Milan, 1920. — 2) FORMENTI, op. cit., p. 188. In the United States commercial use has frequently been made of grape seed residues and lees. Cf. : 1) F. RABAK. The Utilisation of Waste raisin seeds. *U. S, Dept. of Agric. Bureau of Plant Ind., Bull.* No. 276, 1913. — 2) J. H. SHRADER, Commercial Utilisation of Grape Pomace and Stems from the Grape-Juice Industry. *U. S. Dept. of Agric. Bull.* No. 952, 1921.

(3) Good results in extracting this oil have been given by the *wringer* of the Firm "Utrechtsche Machinefabrick" by F. Smulders of Utrecht (Holland). The machinery is composed as follows :— 1) a wooden sifting apparatus with internal exhaust ; 2) a rolling mill with 5 superposed cylinders which pulverise the grape seeds after sifting ; 3) and 4) a feeding arrangement, which is placed over the steam heater in which the meal attains a

use has been made of it, the results of a few trials in Apulia being as a matter of fact unsatisfactory.

Dr. Branchini, Chemist of the Southern Oil factories and Soap works at Bari writes to say that "for the present the factories extracting oil from olive crushings and grape seeds by means of solvents supply residues that are merely excellent fuel."

According to Paris, this fuel gives out 4325 calories and leaves an ash representing 5.6 % of the original weight containing 9 % of phosphoric anhydride and 33 % of potash.

Grapeseed oil is used :— for lighting either by itself or mixed with colza oil, for making soap ; for painting ; the oil from the first pressing if well refined is edible, and has been largely used in Italy during the war for table purposes, generally mixed with olive oil.

The following information may also be of value received direct from the "Distillerie Italiane" of Barletta. In their factory about 500 metric tons of grapeseeds are handled per annum for extraction of oil.

The grape seeds are separated from the distilled residues by winnowing machines and then treated as already described. The meal is also treated with solvents, among which ethylene trichloride is preferred on account of the sureness of its action and its extractive power. Needless to say the oil obtained with solvents cannot be used for food.

The oil obtained by pressure has a bright green colour ; it is used for soft soaps ; treated with sulphuric acid it becomes fit for lighting ; it is not a good illuminant, but it gives off little smoke. Neutralised with soda, deprived of its odour and colour with animal charcoal or fuller's earth, it becomes a very good edible oil which can bear comparison with other oils (colza, soy-bean, cotton-seed, linseed).

It has also been tried as a drying oil with the addition of manganese salts and unexpected results were obtained from its use in the preparation of dark colours.

Owing to its acetyl index (144.5), grape-seed oil might very well be substituted for castor oil (acetyl index, 146.9) in manufacturing oils for "Turkey red". This oil could also be obtained by pressure cold and in that case the oil would be golden yellow and could be directly used as edible oil ; but this process does not give a satisfactory yield.

Estimating the production of grapes in Italy at 6 million metric tons, the grapeseed oil corresponding would amount to 26,640 metric tons, but of course effective extraction can only be made from the grapeseed residues of the distilleries.

Recent analyses by M. André (1) show that the physical and chemical constants of this oil cannot be determined owing to its very

temperature of 60-65° C. ; 5) an oil wringer ; 6) a wall pump ; 7) a chambered-filter press or else a bag filter ; 8) controls and transmission.

180 kg. of grape seeds can be treated in an hour. In a preliminary test with Italian grape seeds, 16.65 % of oil was obtained, with a residue which contained about 7 % of oil (Cf. L. Grimaldi in *L'Italia vinicola ed agraria*, Year XI, No. 42, 1921, p. 653).

(1) *Comptes rendus de l'Acad. des Sc.* Vol. 172, 1921, pp. 1296 and 1413, and Vol. 175, 1922, p. 107.

variable composition. According to that writer the minima and maxima values obtained from 11 samples of the oil were as follows :—

Specific gravity.	0.9103	0.9334
Refractive index	1.4708	1.4772
Saponification No.	171.0	191.1
Iodine No. (Hanus).	94.3	135.0
Saponification No. of acetylized oil. .	189.7	231.8
Acetyl index.	13.3	49.3

The following analyses have been communicated by the " Distillerie Italiane " of Barletta :—

	Oil by pressure	Oil by solvents
Saponification No.	179.3	191.6
Iodine No	94.7	95.0
Specific gravity.	0.9290	0.9530
Acidity No.	8.2	12.36
Acidity in oleic acid	4.3	6.21
Impurities	0	0

Percentage of oil in various specimens of grape-seeds :—

	Oil %	Kind of grape-seed	
Benzene	12.84	virgin	dry
»	12.26	baked	»
»	11.60	»	»
»	12.38	»	»
Tetrachloride of carbon	12.87	virgin	»
Ethylene trichloride.	10.63	baked	»

Admitting — as has been already stated — that the moist lees represent half the weight of the wine and taking the other proportions already indicated the following statistical figures are obtained. As basis the average production of wine (hl = 100 kg.) for the years 1909-1918 is taken (1).

		Wine
Europe (Germany, Austria, Hungary, Spain, France, Italy, Luxembourg, Roumania, Switzerland)	hl.	112,223,821
Africa (Algeria, Tunisia).	»	7,987,796
America (Argentine, Chili, Uruguay) . . .	»	6,956,719
Oceania (Australia)	»	238,239
General total. . . .	hl.	127,406,575

(1) Cfr.: International Institute of Agriculture: *International Yearbook of Agricultural Statistics* 1917-1918, Rome, 1920, p. 107.

Taking the coefficient 0.5 for the moist lees :—

	metric tons
Europe	5,611,191
Africa	399,390
America	347,836
Oceania	11,912
General total . . .	6,370,329

For the general statistics of products derived from grape residues, a reduction of 25 % on the average yield figures is necessary owing to the considerable variation in the composition of grapes according to the vineyard, soil, climate, behaviour of the seasons, etc.; thus for every 100 kg. of fresh residue as it leaves the press may be reckoned :

Absolute alcohol	litres	3
or Brandy at 50°.	»	8.25
Commercial cream of tartar	kg.	1.90
Tartaric acid.	gm.	37.50
Grape-seeds	kg.	11.25

The following total figures result :—

Products	Europe	Africa	America	Oceania	Totals
Absolute alcohol . . . cub. met.	168,335.7	11,981.7	10,435.0	357.3	191,109.7
or Brandy at 50° . . cub. met.	462,923.2	32,949.6	28,696.5	982.7	525,552.0
Cream of tartar . . . . m. tons	106,612.6	7,588.4	6,608.9	226.2	121,036.1
Tartaric acid . . . . . m. tons	2,104.2	149.8	130.4	4.5	2,388.9
Grape seeds . . . . m. tons	631,259.0	44,931.3	39,131.5	1,340.1	716,661.9

Taking the average of 16 kg. of oil per 100 kg. of grape seeds, in view of the statistical figures already calculated, the average quantity of oil corresponding per annum to the grape seeds separated from the lees is as follows :—

	Grapeseeds — metric tons	Oil — metric tons
Europe	631,259	101,001
Africa	44,931	7,189
America	39,131	6,261
Oceania	1,340	214
Totals . . .	716.661	114,665

The graph fig. 88 has been drawn on these totals.

20. — Tomato seed oil.

The remarkable development of the making of tomato preserves, especially in Italy (1), enables factories to obtain as residues large quantities of skins and seeds which can be used as food for livestock (see p. 178); the seeds also furnish oil. The residue after the tomatoes have been pressed for pulp contains :— liquid 70 % — seeds 22 to 24 % — skins 5 to 8 %. To extract the oil the seeds are first separated from the dry skins by sifting and fanning, they are then ground with ordinary millstones. The meal obtained is first moistened, then heated but not roasted, placed in canvas wrappers and lastly subjected to great pressure which expresses the oil.

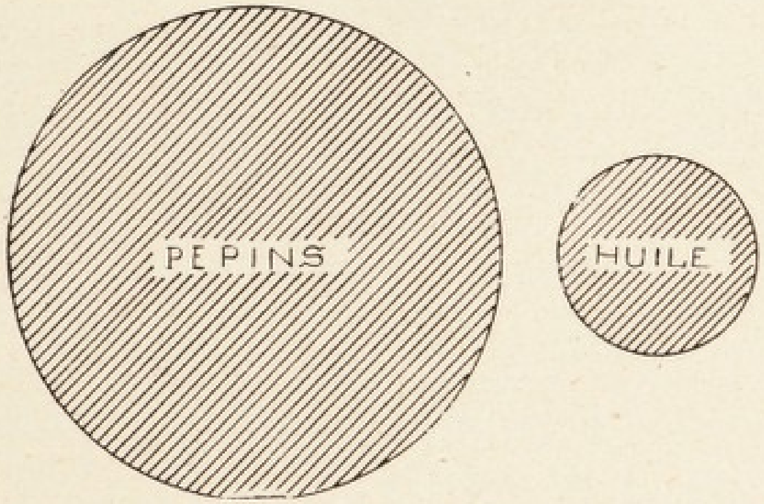


FIG. 88. — Graph representing the average quantity of grape-seeds produced annually in the world and the corresponding quantity of oil.

In the United States (2) many experiments and tests have been made for drying tomato seeds industrially and for extracting the oil.

It has been proved, that seeds dried in trough driers yield a larger amount of oil than those dried in revolving driers. A lighter coloured oil is obtained from seeds dried by the latter process. Impure seeds impart a darker colour, reddish brown, to the oil.

In the cake there remains 2 to 3 % or more of fats which can be

(1) ACCOMAZZO (op. cit., p. 35) states that the Parma preserving factories, alone, produce a quantity of seeds from which 500 m. t. of oil per annum can be extracted.

In 1917, the dry residues of tomatoes from preserving factories in the United States were estimated at 3390 m. tons, capable of furnishing 1560 tons of dry seeds from which oil, extracted by solvents to the extent of 22 %, would represent 343 tons. These quantities are increasing yearly according as the elaboration of the tomato in that country is increased (Cf. *U. S. Dep. of Agr., Bull.* 632, 1917).

(2) Cf. : 1) *U. St. Dep. of Agric. Bull.* No. 927. Washington, April 1921. — 2) F. RABAK. Commercial Utilisation of waste seed from the Tomato-pulping industry. *U. S. Dep. of Agric. Bull.* No. 927. Washington, April 1921.

extracted by bisulphide or tetrachloride of carbon or benzene ; the meal itself can also be directly treated with these solvents.

This oil has the following physical characteristics :— specific gravity at 15° C., 0.920 — refractive index at 25° C., 1.472 — saponification index, 183.6 — ether index 174.1 — iodine index 117 — Reichert-Meissl-Wolny index, 0.22 — iodine index of fatty acids, 129.4 — saponification index of fatty acids, 198.2.

Refining is effected by mixing the oil with a small excess of caustic soda in solution (about 16° Baumé). The oil should be heated (about 65° C.) and kept constantly stirred. The precipitate is allowed to settle

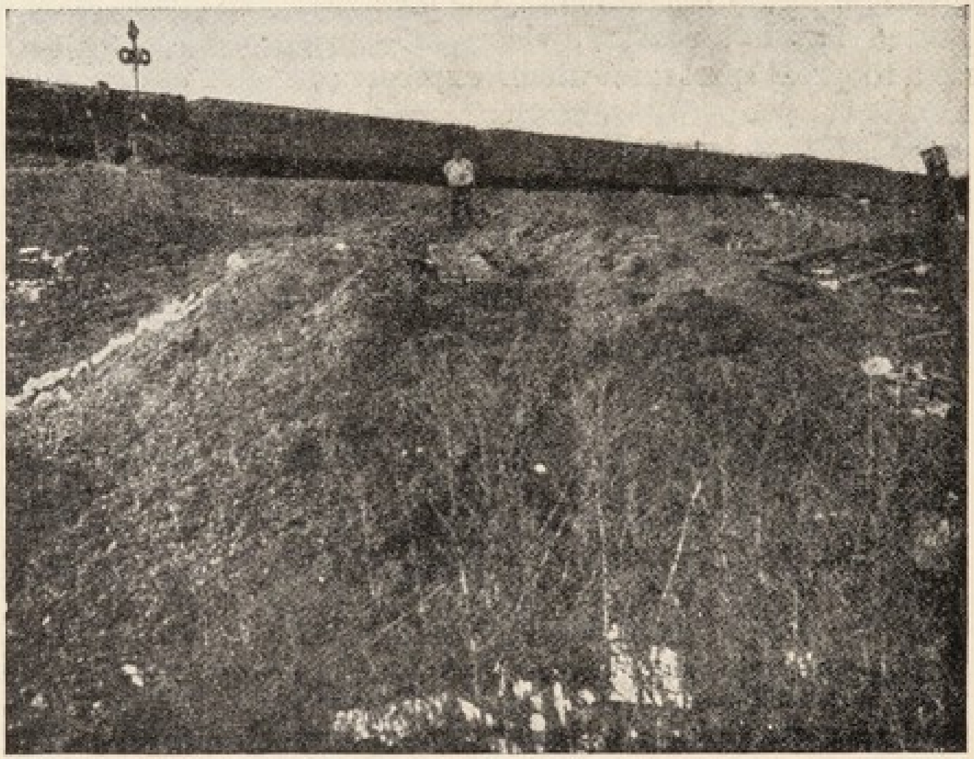


Fig. 89. — Heap of tomato seeds in a preserving factory in the United States.

and is separated by decanting. The best bleaching is obtained at a temperature of 110° C. with 6 % of fuller's earth and 3 % of animal charcoal ; filtering with filter press.

Deodorisation is effected by passing a current of steam at atmospheric pressure and 105° C. for 2 hours. With a vacuum apparatus, an oil not inferior to the edible oils of commerce can be obtained.

Oil extracted by solvents is purified with a solution of caustic soda at 16° B and at 28° C for about 25 minutes. After a few hours the clear oil is separated, heated slowly to 120° C. and treated with 6 % of good fuller's earth. The deodorisation is done in a vacuum at 200° C.

The oil thus obtained with solvents has the same characters as oil obtained by pressure (1).

(1) Cf. *U. S. Dep. of Agric., Bull.* 927. Washington 1921.

This oil serves :— as fuel — for lighting — for soap-making — for the manufacture of oil-varnish — for tanning. It has nearly the combustible properties of olive oil and when it is thoroughly purified it burns with a bright flame. It has also been used, after refining, as food ; in the refined state it has, in fact, a coefficient of digestibility of 97. It could also be hydrogenised and transformed into oleomargarine.

From the experiments which have been made in the United States the most suitable method of using tomato residues appears to be that of separating and collecting the seeds in the preserving factories and

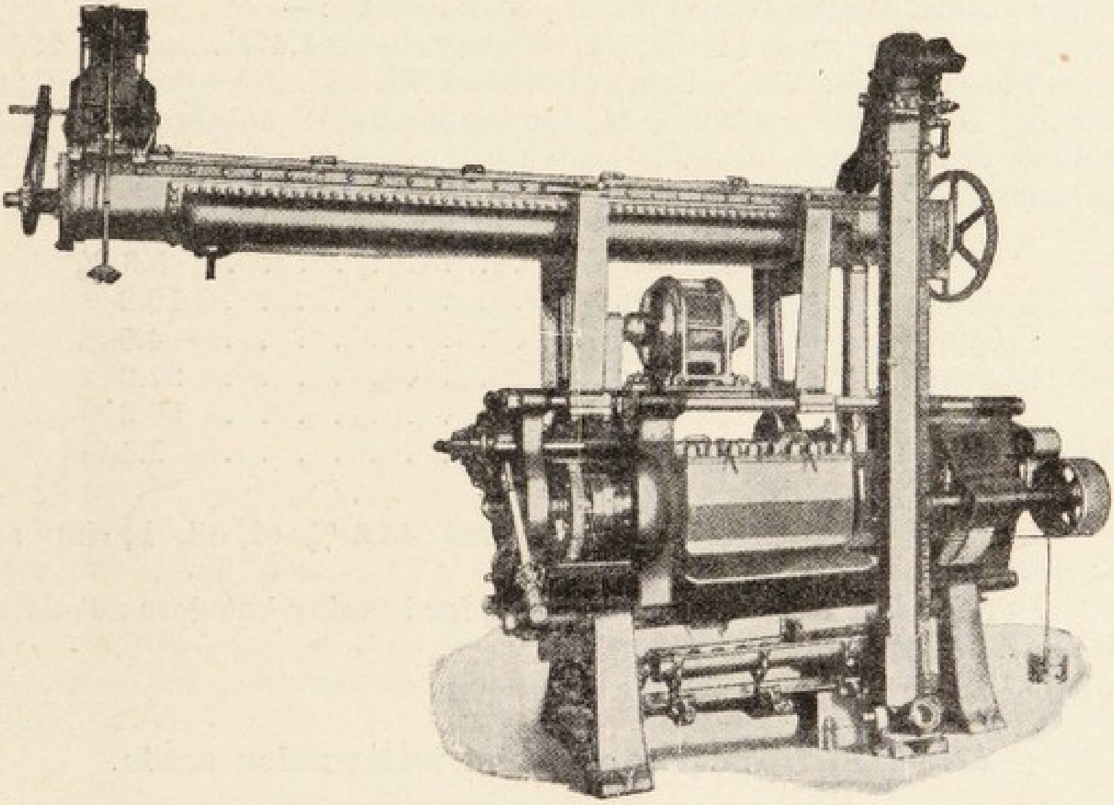


Fig. 90. — Olier press for the extraction of oil from tomato-seeds by pressure (1).
Reproduced from U. S. Depart. of Agric. (Bulletin No. 291). Washington, 1921.

then despatching the whole material collected to a central factory for the extraction of the oil and production of cake. All this should be done by co-operation between the manufacturers.

This utilisation of agricultural residues for the manufacture of products of high commercial value (2) is well worth attention.

(1) This Olier-press works entirely by mechanical pressure and requires no labour ; it can work without stopping day and night, under the supervision of a single man for 5 or 6 presses.

Pressing is done cold, without grinding or better after rough crushing, in a cylindrical barred cage by means of a screw, and the oil runs off into a receptacle placed below. The screw produces an increasing pressure, and the cake is taken out at the end of the extraction box.

The yield and the quality of the oil, with this apparatus are better than those with the ordinary press. The cake contains only 4-5 % of oil (Cf. *L'Ind. Chim.*, No. 97. Paris, February, 1922, p. 12).

(2) Cf. *U. S. Dep. of Agr., Bull.* No. 927. Washington, April 1921.

21. — Melon-seed oil.

Unsaleable melons, which in many places are allowed to rot on the ground, might be utilised it first piled ir heaps to allow of fermentation, the seeds being afterwards separated with a rake.

The writers mentioned in note (1) obtained from a sample of melon-seeds from California by extraction with ether, 39.4 % of oil, the chemical composition of which was as follows :—

Specific gravity at 25° C 0.921, refractive index 1.47, iodine No. 125.9 saponification No. 192,3, Reichert-Meissel No. 0.33, Polenske No. 0.26, acetile No. 15.8, acidity 0.43, non-saponifiable substances % 1.1, soluble acids % 0.4, insoluble acids 94.0, non saturated acids % 79.2, saturated acids % 15.3.

Glycerides of	myristic acid	0.3 %
	palmitic »	10.2
	stearic »	4.5
	oleic »	27.2
	linoleic »	56.6
Non-saponifiable matter		1.1

In these seeds Fendler has found 43.8 % of oil, having an acidity index of 4.81.

In Southern Russia this oil is used for burning but does not enter into trade (2).

22. — Oil from pumpkin and watermelon seeds.

When pumpkins are used for making jam, etc., a large number of seeds are obtained as residue composed on the average of 23.5 % of husk and 76.5 % of kernel (3). The whole seeds contain from 35 to 37.5 % of oil, the kernels from 47 to 48 %. The oil obtained by pressing cold has a greenish colour with red fluorescence. It is siccative, edible and a vermicide. Its characteristics are as follows :— specific gravity at 15° C. = 0.923-0.925 — solidification point = — 16° C. — saponification index = 188.7 — iodine index = 121 — refractive index at 25° C. = 70.2. In Southern Russia pumpkin seeds are pressed hot and a viscous, dark red oil, used for lighting (4) is obtained.

(1) Bangman W. F., Brauns D., Jamieson G. S., in *The Journal of the Chemical Society*. vol. LXII, No. 11, Easton, Pa., 1920.

(2) Dr. J. Lewkovitch, op. cit., Vol. II, p. 127.

(3) 1) Dr. J. Lewkovitch, op. cit., vol. II, p. 124. — 2) Institut Colonial de Marseille. Mémoires et Rapports sur les Matières Grasses. Vol. I. Marseilles, 1922, p. 367, or : op. cit. p. 367.

(4) Allen Rogers, *Industrial Chemistry*, 3rd ed., p. 659. New York, 1921.

In watermelon seeds 62 % is kernel which contains 65.8 % of oil while the whole seeds contain 40.8 %. The characteristics of this oil are as follows :— free fatty acids 1.2 % — specific gravity at 20° C. = 0.9160 — saponification index = 189.7 mg. of KOH — iodine index = 118.

From a complete enquiry made in the United States on oil obtained by cold pressure of the seeds of *Cucurbita maxima* (Hubbard Squash) (1) the following chemico-physical characteristics appear: specific weight at 25° C. 0.918, refractive index at 25° C. 1.4714, iodine no. 121, saponification no. 191.5, Reichert-Meissel no. 0.37, Polenske no. 0.39, acetile no. 27.8, acidity no. 0.50, non-saponifiable substances % 1.06, soluble acids % 0.33, insoluble acids % 94.66, non-saturated acids % 76.45, saturated acids % 18.37.

23. — Oil from strawberry and raspberry seeds.

These seeds may be obtained as residue by centrifugation of the pulp of the fruit in jam and syrup factories. When the quantities available are large enough it is possible to extract an oil, which has the following characteristics (2) :—

Strawberries. — The oil contained in the seeds to the extent of 19 % is siccative like that of linseed. Specific gravity at 15° C. = 0.9345 — saponification index 193.7 — iodine index 180.3 — Reichert-Meissl index 2.1 — refractive index at 25° C. = 1.4790.

Raspberries. — These seeds contain 14.6 % of very siccative oil. Acidity index = 1 — specific gravity at 15° C. = 0.9317 — saponification index = 192.3 — iodine index = 174.8 — Reichert-Meissl index = 0.

24. — Tobacco-seed oil.

According to LEWKOVITCH (3), 9 to 10 % of oil can be extracted from these seeds by pressing and 30 to 32 % by solvents. But in an experiment made in 1920 at Cerignola by the Italian Ministry of Finance, 30 % of oil was obtained from the seeds by pressure equal to 300 atmospheres and 3 to 4 % of oil from the cake by solvents. The yield by pressing should therefore be much greater than this writer indicates. This oil has a yellowish green colour and an agreeable smell, different from that of tobacco. According to G. AMPOLA and SCURTI (4), it contains 3.49 % of fatty acids.

It is a good illuminant and is also regarded as a table oil. It is decidedly siccative : it absorbs 5 % of oxygen in 2 days and 6.84 % in 14 days.

(1) W. F. BANGMAN and G. S. JAMIESON. The Composition of Hubbard Squash Seed Oil. *Journ. of the Amer. Chem. Soc.*, Vol. XLII, No. 1, 1920.

(2) Cf. : Dr. J. LEWKOVITCH, op. cit., Vol. II, p. 113.

(3) Op. cit., vol. II, p. 116.

(4) *Gazzetta Chimica Italiaa*, No. 34. Rome, 1904.

The fatty acids contained in it are :— oleic acid, 25 % — linoleic acid 15 % — palmitic acid, 32 % — stearic acid, traces. Its characteristics are :— specific gravity at 15° C. = 0.9232 — saponification index = 190 — iodine index = 118.6 — insoluble and non saponifiable acids 94.73.

25. — Oils obtained from the kernels of cherries, apricots, plums and peaches.

These oils are well known, but systematic extraction of them whether for industry or for table purposes was developed only during the war in certain countries, notably in Germany ; the material was provided by collecting not only the stones obtained in jam and syrup factories but also those found in household refuse.

According to A. Girard, 100 grammes of fresh fruit contain, on the average, the following quantities of stones (in grammes) :— cherries 6.01-8.60 (according to Rabak 15) — apricots 5.50-7.12 — peaches 5.20-8.38 — plums 4.07-5.65. According to Dr. Hotter's determinations, made in Austria in 1906, the averages vary between 4.4 and 15 gm. for cherries ; 6 and 11 gm. for apricots ; 8.5 and 13 gm. for peaches ; 5.3 and 9.1 gm. for Reine-Claude plums ; 4.7 and 12 gm. for mirabelle plums. These stones have various uses for pastry, confectionery, distilling : distilled liquors, spirits, essences, syrups and ratafias.

As the essence of bitter almonds, mainly found in the stones of peaches and cherries, produces hydrocyanic acid, it is important to avoid using too many of the stones, especially crushed. These stones are preserved for two purposes :— 1) sale to seed merchants ; 2) sowing. They are washed as soon as collected and put to dry on sieves in the air or in the sun but not on a stove as this tends to destroy germinative power. They are then packed in tins or wooden boxes which are kept in a dry and well ventilated place (1).

1) *Cherry* seeds contain 35 to 36 % of oil (2) ; from the whole stones solvents extract 8.3 %. The fresh oil is of a golden yellow colour, it has a faint smell of almonds and a sweet pungent taste ; it becomes rancid with age.

De Negar and Fabris have found a considerable amount of hydrocyanic acid in this oil.

In Southern Germany it is used as an edible oil ; that obtained by pressing hot is used for lighting and soapmaking. Its characteristics are as follows :— specific gravity at 15° C. = 0.9235-0.9285 — solidification point = —19° to —20° C. — saponification index = 193.4 to 195 — iodine index 110.8 to 114.3 — Maumené's test = 45° C. (3).

(1) Cf. *La Nature*, No. 2467. Paris, 1921.

(2) Dr. J. Lewkovitch, op. cit., Vol. II, pp. 225, 227, 229, 231.

(3) *a*) According to M. Rabak the United States could produce 122,000 kg. of cherry kernel oil and 2700 kg. of volatile oil of cherries (Cf. *U. S. Dep. of Agric. Bull.* No. 350, Washington, 1916). This volatile oil is practically identical with that of the bitter almond and can be

From the cake remaining after extraction the essence of bitter almond may be extracted, which is practically identical with that of true almond.

2) *Apricot* kernels contain 40 to 45 % of oil. When the oil is fresh it is almost colourless, then after a time it becomes yellow and has a slight agreeable smell. It is edible and is also used to adulterate oil of almonds. It constitutes an important article of commerce : the oil called " Almond oil, French " is apricot oil pure or mixed with peach oil. The characteristics of apricot kernel oil is as follows :— specific gravity at 15°.5 C. = 0.9211 — saponification index = 179 — acidity index = 1.83 — refractive index at 40°.3 C. = 1.4646 — iodine index = 112.

3) From *plum* kernels 25 % of oil has been obtained by extraction with petroleum ether. It is slightly yellow and has a sweet taste like oil of almonds, which it is used to adulterate. Its characteristics are as follows :— specific gravity at 15° C. = 0.9160 to 0.9195 — solidification point = —5° to —10° C. — saponification index = 189.1-191.5 — iodine index = 91.2-100.4 — Maumené's test = 44°.5 to 45° C. — refractive index at 25° C. = 63.1.

4) *Peach* kernels contain 32.35 % of a light yellow oil much resembling oil of almonds and often used to adulterate it or even to replace it. In turn, peach oil is often adulterated with poppy-seed oil. Its characteristics are as follows :— specific gravity at 15° C. 0.918-0.921 — solidification point = — 20° C. — saponification index = 189.1-192.5 mg. of KOH — iodine index = 92.5-110.1 — Maumené's test = 42°-43° C. — refractive index at 25° C. = 66.1-67.2 (1).

In the manufacture of oils from kernels of stone fruits the crushing of the stones and the separation of the kernels present some difficulty. The specific gravity of the stones being 1.18 and that of the kernels 1.05, K. ALPERS has suggested a novel method of separation (2), based on the use of a solution of chloride of calcium or of magnesium of sp. g. = 1.15. The kernels float in this and are collected in a receptacle with a perforated bottom, washed and dried.

used similarly. Cf. by the same A. : Peach, Apricot and Prune Kernels as By-products of the Fruit Industry of the United States. *U. S. Dep. of Agric. Bureau of Plant Indus.* Bull. No. 133, Washington, 1908. The same writer states that the *juice from stoning cherries* if neutralized yields a good syrup corresponding to 20 % of the juice. By making this juice ferment 4.6 % of alcohol at 95 % strength is obtained. By concentrating it, with the addition of sugar and pectin, an excellent jelly is obtained. From the whole of the juice produced in the United States 19,000 litres of alcohol or 79,000 litres of syrup or 324,000 litres of jelly could be obtained.

b) According to Dr. HEIDE's calculations, 750 t. of oil from the kernels of fruit were produced in Germany during the war (Cfr. KOLLER Dr. TH. op. cit., p. 382).

(1) A. D. HOLMES, Digestibility of some By-Product Oils. *U. S. Dept. of Agric.* Bulletin No. 781, Washington, May, 1919. The author reports that California alone by utilising the kernels of stone fruits could probably produce yearly the following quantities of oil : peaches, 210 to 420 (short) tons, apricots 350 to 400 tons, cherries 134 tons ; and besides tomatoes 343 tons, wine-lees 348 to 464 tons.

(2) Cf. *Chemicker-Zeitung*, Vol. 40, 1916.

The oil obtained by pressure from plum kernels so separated was at first slightly turbid, but it cleared of its own accord: it had an agreeable taste and a strong smell of bitter almonds. The after-taste and smell can be got rid of by passing a current of steam through it, and it thus acquires a very delicate flavour. It also loses its smell when kept for 15 days in an open receptacle.

26. — Oil from mountain-ash berries.

The mountain-ash (*Sorbus aucuparia* L.), which grows among mountains, preferably on the northern slopes, produces berries which are gathered and eaten in winter in the northern regions of Europe.

Its seeds contain 21.9 % of a sweetish tasting, slightly yellowish siccative oil, the characteristics of which are as follows (1):— specific gravity at 15° C. = 0.9137 — refraction index at 15° C. = 1.4753 — saponification index 208 — iodine index 128.5 — iodine index of fatty acids 127.5 — Neutralization index of insoluble fatty acids 230.2.

27. —Arbutus seed oil (2).

In the seeds of *Arbutus Unedo* taken from the residual pulp left from the production of alcohol Professor Sani found 39.03 % of oil, which could be extracted either by pressure or by solvents. It is golden yellow in colour, and tastes sweet: it is a drying oil, and has the following physico-chemical characteristics: specific weight at 15°, 0.9208, point of solidification —27° C., saponification no. 208, iodine no. 147.86, Reichert-Wolny no. 0.861, Maumené degree of heat 103.5, refractive index at 25° C., 71.

According to La Marca the extraction of this oil is of no commercial interest, as the fruits contain very few seeds and the separation of them from the rest of the lees would entail considerable expense not compensated by the value of the oil.

These lees if not given as a feed can often be used as a fertiliser.

28. — Red Currant seed oil.

These seeds (*Ribes rubrum*) contain, in the dry state, 16.9 % of a yellow-brown oil of agreeable smell (3). According to K. Alpers (4), the cake can be used as food for livestock.

It is, of course, a question of utilising the residues from the jam

(1) Dr. J. Lewkovitch, op. cit., Vol. II, p. 107.

(2) Cf.: 1) G. Sani. Intorno all'olio di *Arbutus Unedo*. *Rend. R. Accad. Lincei* 1905, Vol. XVI, 2nd series, p. 619. — 2) F. Lamarca, op. cit.

(3) Dr. J. Lewkovitch, op. cit., Vol. II, p. 789.

(4) K. Alpers, Johannisbeerkerne und deren Oel, in *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, Vol. 32, part II, p. 499. 1916.

factories, in the same way as residues from preserved tomato factories are used. The oil obtained by grinding the seeds, followed by hydraulic pressing, has the following characteristics :— specific gravity at 15° C = 0.9120-0.9288 — solidification point = 17°.5-20° — refractive index at 25° C = 78.1 — saponification index = 171.3-194.5 — Reichert-Meissls' index = 0.77-0.55 — iodine index = 152.5-159.8 — Hehner index = 95.59 — free acids = 23 cubic cm. of NaOH N/1 per 100 of oil — non-saponifiable part = 0.64 %. This oil is siccative : it forms a colourless pellicule in 7 hours at 50° C.

29. — Blackberry-seed oil.

Wild blackberries (fruit of *Rubus* sp.) (Fig. 91) like strawberries and raspberries yield considerable quantities of seeds when the pulp is centrifugated for making jams and syrups.

These seeds contain, on the average, 12.6 % of oil (1) which, if it is obtained by extraction with petroleum ether, has a dark yellowish green colour and a slight red fluorescence. This oil is siccative and has the following characteristics :— acidity index = 2.03 — specific gravity at 15° C. = 0.9256 — saponification index = 189.5 — iodine index = 147.8 — Reichert-Meissl's index = 0.

30. — Oil from orange and lemon pips.

This oil is extracted from pips separated from the pulp by centrifugation in the factories of "agro-cotto" or of citrate of lime or of preserves, and also from the pips of dry fruit, fallen or spoiled, unfit for other uses. Extraction is done by solvents or by pressing.

Lemon-pip oil is paleyellow and has a slight smell recalling that of almonds. The residue from the presses is called in Sicily *pastazzo*, and as a rule no use is made of it. It consists mainly of lemon pips from which the oil may be extracted under pressure with a commercial yield of 25 % of the whole seeds, but after crushing. However a considerable quantity of oil remains in the husks and goes into the cake. From the decorticated seeds 35 % of oil is obtained by the use of solvents. This oil is utilised

FIG. 91. — Blackberry. Flowers, Leaves and Fruits.

FROM Dr. A. FIORI, op. cit.

(1) Dr. J. LEWKOVITCH, op. cit., Vol. II, p. 114.

in making-soap of the Liverpool brand. The cake is a good feeding stuff (1).

According to PETERS and FRERICHS, the acetyl index is 13.65; saponification index = 188.4 mg. of KOH; iodine index = 109.2 %. The fatty acids found in it are palmitic, stearic, oleic and linoleic acids (2).

Orange-pip oil has been extracted by M. HEWIR with petroleum ether to the extent of 37.5 % but the proportion which is obtainable in practice does not exceed 20 to 28 %. This oil has a light yellow colour, is almost odourless and has a taste at first slightly, later increasingly, bitter. It is easily saponified. Its characteristics are as follows :— specific gravity at 15° C. = 0.9208 — saponification index = 193.7 — iodine index = 100.3 — then according to R. MEYER : — refractive index at 21° C. = 1.4714 — insoluble and non-saponifiable acids = 95 — solidification point of fatty acids 35° C. — melting point of fatty acids 40° C. — iodine index of fatty acids 74 (?) — refraction index of fatty acids at 21° C. = 1.4574 = acidity index = 38.3.

31. — Horse-chestnut oil.

It was generally believed, that it was impracticable to extract the fats of horse chestnuts (*Aesculus hyppocastanum*) but this has been done (in small quantities it is true), by means of solvents.

In Germany, the writers indicated in the note (3) reduced whole horse-chestnuts to a meal which they boiled in alcohol, so as to avoid drying (always injurious as it makes the fats liable to decompose) and so as to extract all the saponin possible. They then extracted the fats with ether by the usual methods. They thus obtained 3.23 % of an oil with a peculiar smell and taste, of a dark yellow colour. This yield agrees with that obtained by KÖNIG (4). The characteristics of this oil are as follows :— saponification index 175.5 — Reichert-Meissl's index 1.01 — Polenske's index 0.42 — refractive index at 25° C. = 68.1; at 45 C. = 57.6 — iodine index 99 — acidity 11.67 — non-saponifiable constituents 2.5 % — Hehner's index 92.79.

32. — Beech-mast oil (5).

The beech-masts (fig. 92) falling from beech trees (*Fagus sylvatica*) and collected, either as food for livestock or for the extraction of oil, consist of 33 % of shell and 67 % of kernel containing 43 %

(1) Cf. Prof. B. BERTOLO, L'utilizzazione dei prodotti dell'industria agrumaria, in *Sicilia Ind. e Agr.*, Catania, No. 250, 1 April, 1923.

(2) Cf. 9 1) J. LEWKOVITCH, op. cit. Vol. II, p. 180. — 2) HEWER D. G., *The Analyst*, Vol. LXII, No. 497. London, 1917.

(3) A. HEIDUSKA and A. ZEILEIS, in *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, Vol. 33, 1917.

(4) *Chemie der menschlichen Nahrungs- und Genussmittel*, 4th ed. Vol. I, p. 619.

(5) 1) Dr. J. LEWKOVITCH, op. cit., Vol. II, p. 139. — 2) *Les Matières Grasses*, Year 13, No. 158, 1921, p. 5860. — 3) Dr. G. CASTALDI. Essenze forestali e loro prodotti nelle industrie. Milano, H. Hoepli, 1923, p. 175.

of oil, but the quantity which can be extracted from them industrially by pressure is from 14 to 22 %, as much as 26 % in shelled beechmasts. The average is 15 %.

This oil is produced by small establishments in inconsiderable quantities. That which is obtained by cold process from shelled beechmast is light yellow, viscous, and has a disagreeable smell. It is used in the mountains for cooking. The oil extracted by hot process has an acrid pungency which diappears on stirring it with boiling water.

This is only used for lighting and making soap. It is sometimes used for adulterating oil of almonds and walnut oil, but its presence can be detected by determining the iodine index.

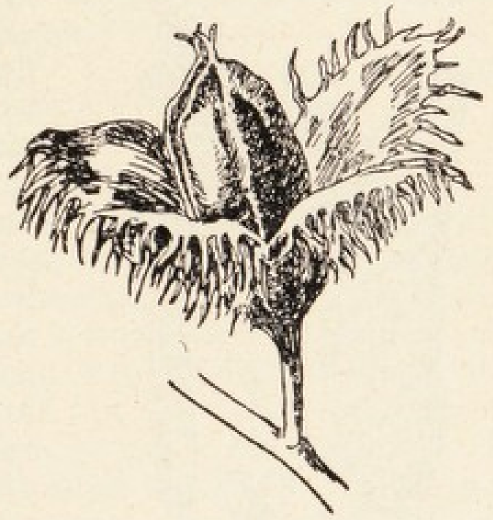


Fig. 92. — Beech-mast.
From Correvon H., op. cit.

The physico-chemical characteristics are as follows :— specific gravity at 15° C. = 0.9205-0.9225 — solidification point = — 17° C. — saponification index = 191.1-196.3 — iodine index = 111.2-120.1 — Maumené's test = 63 to 65 — refractive index = 16.5 to 18.

The cake contains 52 % of protein. The analysis is as follows: Percentage of dry substance: nitrogen 9.52, proteid matter 52.36, N-free extracts 32.64, cellulose 5.8, ash 9.2.

This is at present but little used in Italy for cattle-feed. Pirotta (1) calculates for Italy that there are on an average each year 20,000 hectares (about 50,000 acres) of beechwood in full production. Reckoning for one hectare 50 hl. of beechmast, 100,000 hl. of mast can be produced per year, and from that 15,000 hl. of oil (329,967 gallons).

33. — Spruce seed oil (2).

The seeds of the spruce (*Pinus abies* L.) (Fig. 93) contain, in a dry state, 25 to 30 % of fats on the average. Extraction with ether or with carbon disulphide has yielded 33.2 % of crude fats; extraction with benzene or with benzine has given 30.5 %. The oil extracted by pressing (up to 20 %) is edible; the remainder, which can be extracted by solvents, constitutes an industrial oil, good especially for the prepa-

(1) R. Pirotta and A. Constantino, Utilizzazione di piante alimentari selvatiche. R. Accad. Lincei, Com. Scient. per l'alim. Rome, 1921.

(2) Cf. *Naturwissenschaftliche Zeitschrift für Forst- und Landwirte*, 1916. Summarised in *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel*, Vol. 33, 1917. For the oils from seeds of other conifers cf. also: H. Jumelle *Les Huiles Vegetales*. J. B. Baillière et fils. Paris, 1921.

ration of varnishes and also for lighting. This oil has not the resinous taste of the oil from the seeds of the silver-fir (*Abies pectinata*) because the seeds of the spruce have no resin bearing glands; it recalls groundnut oil by its pale yellow colour ; it is siccative. Its physical characteristics are as follows :— specific gravity at 15° C. = 0.933 — saponification index 191.2 — iodine index (HÜBL) = 173.

As the spruce seeds are rich in albumen the cake can be used as concentrate. For collecting, C. VON TUBEUF recommends picking up the entire cones in autumn or winter as soon as they fall from the trees and keeping them in baskets or sacks. They are then allowed to dry until the seeds fall out naturally. The latter are collected and are then cleaned by cutting the wings with a special machine, after which they are taken to the oil factory. The empty cones serve, like all their congeners, as fuel.

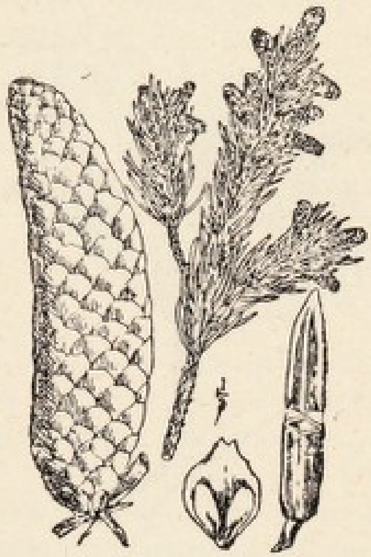


FIG. 93. = Spruce. Branch with flowers and Cone.

From Dr. A. FIORI, op. cit.

This same writer states that this oil is very suitable for salads, frying, mayonnaise, etc., but on the other hand, after having asserted that spruce seed oil extracted cold has little taste, he adds that an egg fried in that oil "had a distinct taste of recently worked coniferous timber", which does not say much for the much vaunted edible qualities of the oil in question. However, it is easy to understand that during the war especially in Germany it was expedient to use it, but since the war, according to PAUL, the high price of spruce seeds for sowing prevents their economical use for the extraction of oil (1).

34. — Lentisk oil.

This oil is derived from the species *Pistacia lentiscus* which grows wild in abundance in the woody and rocky lands of Southern Europe, North Africa, etc. CUPPARI (2) writing many years ago reported that on the wooded sea-coasts, especially near Orbetello, and in Sardinia, the ripe fruits of this plant are gathered by the poorer people, boiled in water, then placed in cloth bags and pressed to extract the juice. When this is boiled in its turn, the oil floats on it and can be separated. In this way a hectolitre (40 kg.) of berries gives about 7 kg. of oil, 17.50 % of the weight. This oil is also extracted in Cyprus, Tripolitania, Algeria, etc. (3).

(1) Cf. J. LEWKOVITCH, op. cit., Vol. II, p. 109.
(2) P. CUPPARI. Lezioni di Agricoltura. Nistri, Pisa, 1869.
(3) H. JUMELLE, op. cit., p. 328.

According to recent investigations made at the Central Customs Chemical Laboratory at Rome (1), the total fat content is 22 %. The oil is dark green in colour, comparatively fluid, with faint aromatic perfume and taste. When left to settle there is a white crystalline mass deposited which melts at 35° to 36° C. If badly prepared it soon goes rancid.

Other experiments made at Turin gave a yield of oil of 22 % pressure. The oil is well adapted for soap-making.

In view of the large quantities of lentisk fruit which could be gathered in the countries mentioned, and on condition that transport to the place of manufacture is available, its utilization by extraction of oil for soap-making would be profitable.

35. — Wool fat.

This is obtained by washing raw wool or by treating it with solvents. In the latter case, the fat remains after distillation of the solvent; when, on the other hand, the wool is washed with soap, the soapy water is collected in receptacles where it is treated with a mineral acid to set free the fat; the liquid is evaporated to obtain the potash salts it holds in solution. The composition of this fat varies considerably between certain limits. When purified, it is put on the market in an anhydrous state (*adeps lanae*) or hydrated (lanoline). The former of these substances has a light yellow colour, is translucent, and has a slight, not disagreeable odour. Although insoluble in water it absorbs considerable quantities of it (up to 80 % of its weight). Lanoline is a mixture of anhydrous fat and water (22 to 25 %) (2).

The chemical composition of this fat is not fully known.

Its physico-chemical characteristics are as follows:— specific gravity at 17° C. = 0.9413–0.9449 — solidification point = 30° — 30°.2 C. — melting point = 31-42°.5 C. — saponification index = 98.3-102.4 mg. of KOH — iodine index = 17.1-28.9. Other fats are recovered from the wool during the processes of manufacture, carding, spinning, felting; these are removed by means of alkaline washing and recovered by means of a mineral acid which sets free the fatty acids.

For the United States the following statistics are available: — 500 million lbs. of raw wool is the quantity annually handled; this yields 75 million pounds of lanoline, normally worth 2.250,000 *dollars* and at present worth 10 million *dollars*; 25 million pounds of carbonate of potash are recovered also from it, at present worth 15 million *dollars*. The fat from this wool is used:— as food — for making soap — for waterproofing shoe leather. Investigation is being made into the

(1) *Giornale di Agric. della Domenica*. Piacenza, 6 May, 1923.

(2) Cf.: Dr. J. LEWKOVITCH, op. cit., Vol. II, p. 744. — 2) S. J. JOHNSTONE, *Potash*, London, John Murray, 1922. — 3) Wool-scouring Wastes for fertilizer purposes in the *American Fertilizer*, No. 9, 1922.

possibility of recovering from the water used for washing the wool the residues described above. At present the greater part of them are lost in the streams into which this water is thrown.

36. — Oil from silkworm chrysalides (1).

In the discussion of these chrysalides as food for livestock (see p. 198) it was noted that they contain a fairly high percentage (16-18 %) of an oil fit for making common soaps and also for extraction of fatty acids of glycerine. That oil has a reddish brown colour and a nauseating smell. It is purified by being treated with sulphuric acid at 50° B. for 1 hour at a temperature of 100° C., then by washing it and treating it with kaolin or fuller's earth in 10 to 12 % proportion. Its characteristics are as follows : — specific gravity at 40° C. = 0.9105 — solidification point = 10°-7° C. — saponification index = 190 — iodine index = 116.3 — non-saponifiable matter = 2.61 % — acidity index = 27.51 — solidification point of the insoluble fatty acids = 34°.5 C.

37. — Fats from household refuse (2).

In reference to the use of street-sweepings as manure (see p. 303) mention was made of the special treatment to which they are subjected for the extraction of fats. With this object a solvent was first employed, but this process proved too expensive. The steam treatment (ARNOLD-EGERTON) process is much better, and the requisite appliances for this are in use in several towns in the United States.

After removal of all extraneous matter, the street-sweepings are placed in large digesters (holding about 8 tons), in which they are steamed to boiling point, the digesters are then hermetically closed and steam under a pressure of 89 lbs. is introduced for a time varying according to the material and the season of the year. The steam given off is condensed and the resulting water is passed to the sewers. After the action of the steam is over, the contents of the digesters separate into three layers : the lowest is the solid matter ("tankage"), above this is a layer of water and on that floats a layer of fat. This fat is used for making common soaps, etc. It is of a dark brown colour and contains a considerable quantity of free fatty acids, as well as non-saponifiable matter (3).

(1) Cf. : 1) FORMENTI, op. cit. — 2) J. K. LEWKOVITCH, op. cit., Vol. II, p. 392. — 3) Dr. G. COLOMBO, Sunto delle Lezioni di Merceologia e Tecnologia dei bozzoli e della seta, Milan, 1917. Fratelli Lanzani.

(2) Dr. J. LEWKOVITCH, op. cit., Vol. III, p. 366. Cf. also : 1) A. CALMETTE, Epuration des eaux d'égout urbaines et industrielles, Paris, J. B. Baillière, 1910, p. 26. — 2) Ing. F. LACCETTI, Fognatura Biologica. Milan, U. Hoepli, 1915, pp. 152 and 220. — 3) Dr. S. RIZZI, L'epurazione biologica delle acque di rifiuto. Milan, U. Hoepli, 1915, p. 86.

(3) Cf. R. PEARL. Statistics of Garbage collection and Garbage grease recovery in American cities. *Jour. of Ind. and Engin. Chem.*, Vol. 10, No. 11, p. 297, Nov. 1918.

The tankage is subjected to hydraulic pressure which extracts from it along with water the fats it still retains. It is then dried, ground and sold as fertiliser.

38. — Fats from sewage water (1).

This water, already discussed as a fertiliser (see p. 296) contains fats in various forms: saponified — non-saponified — free fatty acids — non-saponifiable matter.

As all these matters putrefy very readily processes have been investigated with a view to destroying them as quickly as possible. In the process by *precipitation*, the fats are entirely destroyed by bacterial action. Other processes, however, aim at separating the fats, one of the most usual is the method in use for recovering wool-grease, viz.: washing in soapy water and then treating the water with a mineral acid. But so far it has not proved possible to apply any process with economic advantage, so that for the present it is better to aim at the prompt destruction of the matter carried in sewage water, or to use it for irrigation purposes.

39. — Fats from soil organisms (2).

Edaphon or putrid mud ("Faulschlamm") is the name given by R. FRANCÉ to a fat of bacterial origin which he discovered in certain soils in Germany, where certain bacteria are found containing fats which do not solidify even at very low temperatures. This fat can be employed for technical purposes and in the manufacture of soap.

These micro-organisms are algae and fungi. Nearly half their volume consists of fatty matter.

A process has been patented for the extraction of fat from soils containing an average of 100,000 of these micro-organisms to a cubic centimetre.

In the most favourable conditions 7 % in volume of fats are obtained by the ordinary solvents from these soils; the residue constitutes a nitrogenous manure.

(1) 1) Dr. J. LEWKOVITCH, op. cit., Vol. III, p. 366. 2) For the separation of fats from sewage water the KRAEMER and SCHILLING apparatus manufactured by the "Gesellschaft für Verwertung Städtischer Abwasser in Frankfurt a. M." is indicated. That apparatus separates only 40-70 % of the fats contained in the water. There is also a PAULMAN method, patented, which is said to be more efficient, but which is not described.

Other apparatus which have been used for such extraction are that of the "Deutsche Wasserreiningungsgesellschaft" of Wiesbaden which separates fats from the sludge by means of the passage of water through three concentric cylinders; that of the "Fettfänger H. Dorfmüller" of München, and that of the German patent No. 300,218 (Cf. KOLLER Dr. Th., op. cit., p. 134-136).

(2) Cf. KOLLER, Dr. Th., op. cit., p. 113.

40. — Wine making residues.

Besides the principal residue, the grape skins, already mentioned in connection with grape seeds, the wine making industry obtains still further residues of the fermentation of the must and of the maturation of the wine, viz : the lees, which are deposited on the bottom and the sides of the wine vessels. Industrial products :—tartars,oenocyanin, alcohol, acetic acid, tannin, etc. are obtained from these residues.

The lees, etc., contain all the compounds of tartaric acid namely, chiefly bitartrate of potash and tartrate of calcium ; the percentage of these determines the richness of the residues, and consequently their commercial value.

The content in *cream of tartar of the residues* varies considerably acording to the vines and also according as the residue is fresh or fermented : when fermented the percentage of cream of tartar is always greater by some units : for example 3.2 % against 1.9 % in the former ; this percentage may even be as much as 5 to 6 %.

The cream of tartar is extracted from the residues by washing them with hot water in the proportion of about 2 hectolitres per 100 kg., boiling for 2 or 3 hours. The liquid is then poured into casks or vats. In these there are strings stretched in various directions on which the cream of tartar is deposited as crystals, as well as on the sides, while the liquid is cooling. The mother-waters, still containing a little cream of tartar in solution, are again subjected to 5 or 6 successive crystallizations and then thrown away.

The *mother liquor of the cream of tartar* contains cream and many pectic and albuminous substances. The residual cream is precipitated with milk of lime, as calcium tartrate, which when treated with potassium bisulphate gives cream of tartar. To the mother liquor when deprived of the cream lime is added and a precipitate of phosphates and albuminoids is obtained which is useful as a fertiliser (1).

Cream of tartar is also extracted from distilled residues by other processes :— high pressure, circulation of hot water, etc.

From non-distilled residues cream of tartar is extracted by various processes, the simplest of which is that with hot water.

Cream of tartar is also extracted by the following chemical processes: 1) treatment with sodium carbonate ; 2) treatment with hydrochloric acid (to liberate $C^4\ H^6\ O^6$ ac. tart.) and then with milk of lime (to obtain $C^4\ H^4\ Ca\ O^6$ tartr. calc.); 3) treatment with sulphurous acid.

The crude tartar from residue is then refined by successive crystallizations, the tartaric acid is then extracted from it.

The *wine lees* are collected in bags and then pressed. The liquid which runs off serves for making alcohol or vinegar ; the pressed lees are dried in the air and cream of tartar is extracted from them with hot water, as is done with the other residues, thus obtaining the " lees

(1) Cf. Dr. G. Ciapetti. Industria tartarica. U. Hoepli, Milan, 1907.

crystals". The lees are rich in cream of tartar; containing when dry from 15 to 60 %, besides 2 to 20 % of tartrate of calcium.

Taking wine during its first 6 years OTTAVI and MARESCALCHI (1) estimate the quantity of commercially dry lees obtainable at 1 kg. per hectolitre of wine.

Cask tartar is a crystalline deposit left by the wine as it ages. It is rich in bitartrate of potassium, tartrate of calcium and free tartaric acid.

On the average, according to the above-mentioned writers, the quantity of tartar which is deposited varies, in one year, from 150 to 300 gm. per hectolitre of wine; in large cellars, it may be estimated that 10 hectolitres yield on the average 2 kg. of tartar per year.

According to SOXHLET, the percentage of cream of tartar in the tartar varies between 70 and 75 %, but it is often less.

The *dregs* are the residues from the vessel in which the crystallization of the tartar and the washing of the lees is done. If the operation is properly carried out very little cream of tartar remains in these residues, which have a certain value as fertilizers.

There are besides the dregs of the *neutralisation of the must*, carried out by means of milk of lime, or of carbonate of lime, or of alkaline substances. These usually collect on the web of the press filters. Their composition varies but they always contains calcium tartrate, bi-tartrate, and neutral potassium tartrate.

Tartaric acid is extracted from these by the usual methods.

To complete the enumeration of the tartaric residues, mention may also be made of the *crystals of alambic* which form in apparatus for distilling the residues and lees and which are composed of crude cream of tartar.

Sour residues serve for the manufacture of *basic acetate of copper*, used as an efficient fungicide instead of sulphate of copper and sometimes giving better results than the latter. It is also used in dyeworks, for the manufacture of varnish, etc.

Under the name "*verdet bleu*" a mixture of neutral acetate and basic acetate (containing up to 33 % of copper) is sold in France and, under the name "*verdet gris*", a mixture of bibasic and tribasic acetate (containing up to 50 % of copper).

At Montpellier (France) verdigris has been manufactured since the XV century by arranging sour residue in alternate layers with oxidized sheets of copper, in damp cellars. Contact lasts for 30 to 40 days, at the end of which the copper sheets are removed and the acetate formed is detached from them.

After the residues have been put to all these various uses, or when for some reason they are not suitable for such, they are utilised for fuel, or put on to the manure-heap (2).

(1) 1) Cf. OTTAVI-MARESCALCHI, *I residui della vinificazione*, p. 227. Casale, 1901 2) P. COSTE-FLORET. Les résidus de la vendange. Coulet et fils, Montpellier, 1901.

(2) Cf.: 1) *Comptes rendus de l'Académie des Sciences*, Vol. 145, No. 21. Paris, 1917. — 2) OTTAVI and MARESCALCHI, op. cit., p. 153.

As fuel, the residues are reckoned to have the same calorific value as peat (3500 to 4000 calories) and about the same percentage of ash. Like peat, they can be treated in special retorts for the production of gas for lighting. The grape seeds, owing to the fat which they contain, yield twice as much illuminating gas as the residues.

The residue from the carbonization of wine lees if not raised above red heat constitutes, after washing, *Frankfort black*, charcoal which is sold dry and ground as paint.

It is calculated that the residue from 1 million hectolitres of wine produced is equivalent as fuel to 3200 tons of coal.

41. — Liquor from tomato pulp.

This is the liquor extracted by pressing and centrifugation of tomato pulp. It is reddish, sweetish and ferments easily. It can be used for making vinegar, but acetic fermentation is difficult to obtain because it degenerates very easily into putrid fermentation. A little phosphate of ammonia is at first necessary to encourage multiplication. But even so it is difficult to get a result.

To accelerate acetification receptacles filled with cork chips or parings might be used.

Cork chips according to KOLLER (1) have the property of maintaining their elasticity even when wet, and in the pores a large number of micro-organisms are harboured, among which the bacteria of acetification preponderate, so that acetification progresses fairly rapidly.

It may be noted that the product obtained is not a true vinegar (2) as its normal acidity is due to the lactic acid. It rapidly deteriorates as has been said unless kept in full and well sealed bottles.

42. — Cellulose of liquorice residues.

Liquorice (*Glycyrhiza glabra* L.) (fig. 94) is a leguminous plant which grows spontaneously in various countries, especially in the South of Europe and Asia-Minor. In Calabria and Sicily, it is also cultivated in the vineyards for its roots, which cut in pieces and dried are sold to manufacturers of liquorice juice, the many uses of which in pharmacy and liqueur making are well known (3). The residue from that manufacture is called in Italy "*rifatto di liquirizia*" (liquorice residue); this is the woody part which remains after the juice has been extracted from the roots.

(1) KOLLER TH., The Utilisation of Waste Products, trans. from the 2nd German edition. London, Scott, Greenwood and Son, 1918, p. 92.

(2) *Making Vinegar in the Home*. U. S. Dept. of Agric. Washington, March 1, 1919.

(3) In the two years 1919-20 Italy exported 1,931.2 m. tons of liquorice root and 1,680 of juice, for a total value of 27,018,100 liras. Cf. Min. per l'Ind. e il Commercio. Il nostro commercio prima e dopo la guerra. Rome, 1922, p. 69.

By a method studied by S. DI PALMA (1), still more juice is extracted from the "*rifatto*" and there then remains a waste product containing 50 % of crude cellulose with fine fibres, of a red brown colour.

This cellulose has been used for making paper, with good results. Besides this principal residue, liquorice also leaves a slime on the filter strainer. The residue and the slime still contain a perceptible amount of glycyrhizin which is ordinarily lost (2).

43. — Cellulose of cotton stalks (3).

The *stalks of the cotton bush* are used as fuel in most cotton producing countries ; in England, the United States and Egypt attempts have been made to extract the fibre of the bark which has, approximately, the characteristics of jute fibre, but without economic result although it was recognised in Egypt that the long fibres could be used like first-class Indian jute.

FIG. 94. — Liquorice.
From FRANCÉ, op. cit.

At the Imperial Institute and in the United States experiments have been made in the production of paper pulp from cotton stalks by extraction of the fibre by means of a barking machine followed by caustic soda treatment, but the yield was scarcely 34-41 % (5 t. of stalks gave 1 t. of bark which produced 1500 lbs. of fibre). In spite of this the results were considered fairly promising and worth further experiment. At the Imperial Institute, an examination was made of the results of an experiment undertaken in Egypt for using cotton stalks to obtain charcoal and the products of dry distillation. The results were fairly good, but it was pointed out that the profitable

(1) *Le Stazioni sperimentali agrarie italiane*, Vol. LIV, part. 10-11, Modena, 1920.

(2) Cf. P. BERTOLO, I difetti dell'attuale processo di lavorazione industriale della Liquirizia, in *Giorn. di Chim. Ind. ed Appl.*, Year III, No. 11, Milan, 1921.

(3) *Bull. of the Imperial Institute*, vol. XIX, No. 1, London, 1921, p. 13.

distillation of cotton stalks depends on the discovery of a local market for the products, which are chiefly charcoal and tar.

As to cost of distillation it was clear that these stalks constituted a material of large volume which required large capacity in the retorts, even if the stalks were first chopped and pressed.

Numerous other cellulose residues have been tried or actually used in the manufacture of paper; the long stalks of maize and buckwheat may be instanced, as also rice-straw, cotton bolls, cane-trash, the coarse fibre of flax and hemp grown for seed, and the refuse from retting of textile fibres in general; many wild plants, in particular esparto grass, plant debris of many kinds, etc. etc. (1).

44. — Extraction of the vegetable pectin of fruit residues (2).

Pectin is a neutral gelatinous substance extracted from fruit, and according to BAUER is a mixture of carbohydrates, soluble in water, and due to the transformation which the fruit acids bring about in the pectose, not itself soluble.

Pectin is extracted from refuse fruit as from cider lees. These are treated with boiling water or steam, then firmly pressed and after clarification — the lime being precipitated with oxalic acid and the albumen with tannin — the pectin solution is concentrated in a vacuum apparatus up to the required density.

There are various patents, especially in the United States for purifying the pectin solution and for its employment in the manufacture of fruit jellies, syrups, etc.

Once it is sterilised and kept in a well sealed receptacle with the air excluded pectin solution keeps for an indefinite time, and it is in this form that it is sold by various American manufacturing firms (3).

(1) Cf.: 1) Ch. J. BRAND. Crop Plants for paper making. *U. S. Dept. of Agr. Circ.* No. 82. 1911. — 2) J. L. MERRILL. Utilisation of American Flax straw in the Paper and Fiber-board Industry: *U. S. Dept. of Agric. Bull.* No. 322, 1916. — 3) L. H. DEWEY and J. L. MERRILL. Hemp hurds as paper making material. *U. S. Dep. of Agric. Bull.* No. 404, 1916.

(2) Cf.: 1) *Washington Agric. Experim. Stat. Bull.* 147. Pullman, Washington. "A New Method for the preparation of Pectin". — 2) *Science*, Vol. 47 (1918) No. 1224: "A New and Improved Method for obtaining Pectin from Fruits and Vegetables". — 3) C. A. SHINKLE. Methods of Manufacturing Preserves, Pickles, etc. Menominee, Michigan. — 4) FREMY. Enc. Chem. Vol. VI, Part II, p. 436, Paris 1885.

(3) Among these the following: 1) *Schwartzlose and Beylik*, Los Angeles, Calif. — 2) *Douglas Packing Co.*, Rochester, N. Y. — 3) *Paoli Tomato Products Co.*, Paoli, Ind. — 4) *C. E. Rogers*, Detroit, Mich. — 5) The *Greenwald Vinegar Co.* St. Joseph, Montana (dry pectin mixed with sugar).

SUBJECT INDEX

INDEX OF AUTHORS

LIST OF ILLUSTRATIONS