Some points in the analysis of meat extracts and allied preparations, with notes on their dietetic value : being the results of a series of analyses / performed by Professor Hugh Galt ... in the public health laboratory of Glasgow University during session 1898-99.

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BEING THE RESULTS OF A SERIES OF ANALYSES PERFORMED BY

PROFESSOR HUGH GALT, M.B., D.P.H.(Camb.),

IN THE PUBLIC HEALTH LABORATORY OF GLASGOW UNIVERSITY DURING SESSION 1898-99.

PHILOSOPHICAL SOCIETY OF GLASGOW.

1900-1901.

With the author's compliments.

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[From the *Proceedings* of the Philosophical Society of Glasgow.]

Some Points in the Analysis of Meat Extracts and Allied Preparations, with Notes on their Dietetic Value. Being the results of a series of analyses performed by Professor HUGH GALT, M.B., D.P.H.(Camb.), in the Public Health Laboratory of Glasgow University, during Session 1898-99.

[Read before the Society, 19th December, 1900.]

The use of condensed and more or less liquid preparations of meat, in the dietary of invalids especially, has only come into prominence within comparatively recent years, although "extract of meat" was described early in this century.* For some time a meat extract remained a curiosity of the laboratory, and only about 1847 was its manufacture on a commercial scale initiated by Liebig; in fact, not until about 1860 was there a real extract of meat in the market. For some years "Liebig's Extract" enjoyed a monoply, but its commercial success—due, partly, to judicious advertising, as well as to its portability, keeping properties, and meaty flavour—soon brought a number of competitors on the scene; and we suffer now from a plethora of such preparations, a large proportion of which differ from each other only very slightly.

The published analyses of Liebig's Extract went to show that it was rich in nitrogen, and that it contained a considerable percentage of peptones and "meat bases." Clinically, it was found that, given with hot water, it had a powerful and rapid stimulant action, and was of the utmost value in cases where such a stimulant was required, and where alcohol would have been deleterious.

In all the subsequent preparations attempts were made to improve upon Liebig's preparation in various directions, while still preserving the main characteristics.

Looking at the tabulated results of chemical analysis of the different preparations, considerable diversity is evident with regard to some of the constitutents. The diversity, however, is

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* Proust, 1801.

largely due, in many cases, to the differing percentage of water, or at least of matters volatile at 100°C ; in other words depends a good deal upon whether the preparation is liquid (the so-called "Meat Juices") or pasty.

It must be clearly evident that chemical analysis alone is of very limited utility in determining the value of a meat extract, much in the same way as a chemical examination of water may be very misleading, as it takes no cognisance of the possible presence of pathogenic organisms.

Of late years an attempt has been made to increase the nutritive value of meat extracts, chiefly by extracting the meat without the aid of heat and thus obtaining a considerable proportion of uncoagulated meat albumen. On the preceding lies a very important part of the whole question of the value of meat extracts. For some time it was denied that meat extracts, as previously prepared, had any appreciable nutritive value at all, and that their sole value was as rapidly diffusible animal stimulants. It was to overcome this that the method of preparation was in some cases altered so as to preserve the nutrient constituents which had formerly been, partly at least, lost ; so that now we have a number of preparations claiming to be highly nutritive as well as stimulating. Let us examine this claim a little closely. It may be admitted (see published tables of analyses) that several preparations contain a considerable proportion of albumen amongst their solid constituents, and if it could be shown, 1st, That the albumen is all derived from the meat, 2nd, That meat albumen has special advantages over, say, egg albumen, and 3rd, *That the percentage of meat bases is not diminished*, there is no doubt that the advantage would be considerable. Unfortunately for the case of the "nutritive" meat extracts the second point, as far as we know, cannot be conceded ; and thus, even if the first condition is present, the whole case of the special advantages of a meat extract containing a large proportion of albumen falls, in my opinion, to the ground, as there is almost invariably a drop in the proportion of meat bases present in such extracts. It is well known that, in some of the preparations, albumen is artificially added ; and although the nutritive value is there, it is a value not peculiar to meat extracts. This being in a sense a negative argument does not, so far, militate against the use of meat extracts as nutrient media, but whether this use is advisable otherwise, is another question.

As a matter of fact, in the earlier preparations the albumen was purposely got rid of by coagulation, as the result was found to be a more stimulating preparation. This is what we might *a priori* expect.

If the addition of albumen is to be held as legitimate, I see no good reason why carbohydrates and fats should not be added also, and the result brought out as another "perfect food."

In the present investigation, I have confined myself to the chemical examination of the main constituents of a selected number of meat extracts and allied preparations, and to the microscopic characteristics of the preparations.

The differentiation of the "total nitrogen" was comparatively easy up to and including syntonin, but beyond that the most careful examination yielded results differing so much as to render their value *nil* and their rejection imperative. To even partially overcome the difficulty it would have been necessary to use large quantities for analysis, and as this investigation is not intended as an exhaustive chemical analysis of the meat extracts, it did not seem advisable to carry the examination further.

Stutzer's method for differentiating the nitrogen [as described in Zeit. Anal. Chem. for 1895] is that usually employed; but the grave objection to this method is that by the use of phosphotungstic acid as a precipitant of the peptones a variable and rather large proportion of the meat bases are at the same time precipitated and reckoned as peptones. Kemmerich's method of fractional precipitation with different strengths of alcohol (Zeit. Phy. Chem. for 1894) has also been shown by König and Bomer to be unreliable in estimating peptones and meat bases. Schjerning's "halogen" method seems to be least objectionable, but sufficient data have not yet been obtained to prove that it is both constant and accurate in its results.

Subjoined is a tabular statement of the results obtained by me, expressed in percentages :—

Name of preparation.	Loss on evaporation at 100°C. Calculated as Moisture.	Total Solids.	Ash.	Chlorides	Fat.	Total Nitrogen.
Armour's Extract of Meat -	20·049	79·951	26·47	7·720	·250	8·256
Bovinine, - -	80·110	19·890	*1·399	1·050	·039	2·500
Bovril (seasoned),	42·730	57·270	18·820	8·309	2·250	7·080
Liebig Co.'s Extract,	14·855	85·145	24·920	5·860	·018	9·143
Lipton's Extract of Beef, - -	16·760	83·240	21·829	10·101	·080	8·733
Valentine's Meat Juice, - -	55·160	44·840	10·821	2·550	·050	2·850
Wyeth's Beef Juice,	63·534	36·466	13·870	6·763	·085	2·976

It may be convenient at this place to discuss shortly the points of importance with regard to the analytical methods employed.

1st, *The loss on evaporation* (at 100°C.) *calculated as moisture.*

It is evident that while, in what may be termed a *pure* meat juice or meat extract, the loss of weight may be accepted as entirely due to moisture, this does not necessarily hold good, as matters volatile at or under 100°C. are sometimes added to such preparations as preservative agents. This introduces a fallacy if the loss is put down simply as water; but the fallacy is of no great moment, as the loss is either moisture *in toto* or moisture *plus* some added volatile matter, neither of which plays any essential part in the action of meat extract from a dietetic point of view.

Of the various methods of estimating this "loss on evaporation," I unhesitatingly give first place to that performed with asbestos. The extract, made into a very thin liquid by the addition of sufficient distilled water, is distributed in a large shallow capsule of tinfoil over a quantity of recently ignited asbestos wool sufficient to more than absorb the whole, and kept at 100°C. in a water bath till the weight is constant. This gives accurate and rapid results, and is much superior in every way to simple evaporation by Stutzer's method, using sand in place of asbestos.

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* This ash is rich in ferric salts.

2nd, *Total Solids.*

As fresh lean meat contains, roughly, 75 per cent. of water, it is evident that preparations losing more than this on evaporation contain less solid matter than ordinary meat, and can hardly be termed concentrated foods. On the other hand, a high percentage of "total solids" is no guarantee of high nutritive or even stimulant value; as the solids may and often do include a large relative proportion of sodium chloride.

As to the estimation of the solids nothing need be said, as the figure follows from the loss on evaporation.

3rd, *Ash.*

In the estimation of the ash great caution must be observed, else most discrepant results will be obtained. The heat must be very gentle at first so as to allow slow carbonization of the mass, thereafter increasing the heat very gradually so as to avoid partial volatilization of the chlorides. The operation should be conducted in the absence of any approach to a draught, and the ultimate weighing performed as rapidly as possible when the capsule is removed from the dessicator, as the ash is in all cases hygroscopic.

It is often difficult to get the last of the black specks (which include carbonaceous matter) converted into true ash, and the operation cannot be considered complete until the ash is of a uniform whitish-grey colour.

The small percentage of ash relative to the total solids in Bovinine is noteworthy.

4th, *Chlorides.*

The interest in the estimation of chlorides turns upon the question of added sodium chloride. A certain proportion of chlorides (mainly potassium chloride) is normally present in all such preparations, but it will be found that in most cases there are added chlorides, and as these are neither nutritive nor stimulant their presence in excess can only be regarded as an impurity, as they are added for preservative purposes merely.

Further, sodium chloride taken in large excess is a cardiac depressant, and may even be actually poisonous unless a large excess of water is also taken.

The following table shows the added chlorides (calculated as sodium chloride) present in the preparations examined :—reckoning ·06 per cent. for each 1 per cent. of "total solids." *

* Allen : Commercial Organic Analysis, Vol. IV.

Armour's Extract of Meat, - - -	2·929 per cent.
Bovinine, - - - - - -	0·0 ,,
Bovril, - - - - - -	4·873 ,,
Liebig's Extract, - - - -	0·752
Lipton's Extract, - - - -	5·107
Valentine's Meat Juice, - - -	0·0
Wyeth's Beef Juice, - - - -	4·575

The results shown by this table are highly interesting, but one ource of possible fallacy must be pointed out. The normal percentage of chloride present in lean meat (·06 per cent. for every 1 per cent. of total solids) is calculated on the assumption that the "total solids" are entirely derived from the meat. That this is not always the case is well known; albumen and gelatine, for example, are sometimes added from extraneous sources, and thus the co-relation of total solids and chlorides is interfered with. Further, reference to the table of "microscopic appearances" (pages 11 *et seq.*), shows that in some cases matters entirely foreign to meat go to swell the proportion of total solids present.

There can be no doubt that from a dietetic point of view the presence of chlorides in excess is prejudicial. It is a matter of common knowledge that salted foods are of comparatively low dietetic value. Salt in excess impairs or destroys the flavour, thus interfering with the quality of *sapidity* which plays a not unimportant part in the value of any food. Apart from its action on the flavour, an excess of common salt alters the constitution of the meat juices, and coagulates, partially at least, some of its constituents. Its addition to meat extracts is for the purpose of preservation, and (from its hygroscopic property), of assisting to keep the extract in a pasty condition.*

In the liquid preparations of meat a liquid preservative can be employed (for example, alcohol or chloroform is used in Bovinine), and there is no use otherwise for added salt. In this connection it is interesting to note that in Bovinine and Valentine's Meat Juice not only is there no added sodium chloride, but the proportion is even rather less than should be normally present, judged by the percentage of total solids.

The estimation of the chlorides was performed in the usual way, by means of $\frac{N}{10}$ $AgNO_3$ with K_2CO_4 as indicator, the ash being

* Pure sodium chloride is not hygroscopic, but common salt, containing traces of magnesium chloride as an impurity, is markedly so.

lixiviated with repeated small quantities of hot distilled water.

5th, *Fat.*

Any appreciable quantity of fat in a meat extract can only be regarded as an impurity *qua* the object intended, and we accordingly find that as a rule fat is present in extremely minute proportions, the one exception being Bovril. The percentage obtained in the case of Bovril is the average of analyses of three samples obtained from different sources.

With regard to the method of estimation, some points are worthy of notice. On the advice of Professor Glaister, and according also to the method recommended by Allen,† I employed petroleum ether. I found, however, that even with the best redistilled petroleum ether which could be obtained, it was impossible, using Soxhlet's apparatus to get the last portions of ether driven over by means of a water-bath, and I had finally to fall back on repeatedly exhausting the dry and powdered extract with petroleum ether, filtering and allowing the ether to spontaneously evaporate in a free current of air. This method gave very consistent results. On the other hand, when anhydrous sulphuric ether was employed, the results were invariably higher, and also fluctuated considerably.‡

6th, *Total Nitrogen.*

The most striking point here, is the close approximation of the percentages, the figures ranging from, roughly, seven to nine in the case of the pasty extracts, and from two and a half to three in the case of the liquid ones.

For a long time the percentage of total nitrogen was looked upon more or less as an index of the food value of the preparation. This, of course, is erroneous. As previously pointed out, any real nutritive value in such preparations must be extremely small, and is entirely subservient to their value as animal stimulants. If it were certain that no extraneous matters were added, the total nitrogen present would have a certain value as indicating a larger or smaller proportion of nitrogen-containing *meat bases*, upon which the stimulant value of meat extracts depends. But for reasons already stated, the "total solids" may not be altogether

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* See Table on page 6.

† Commercial Organic Analysis, Vol. IV., p. 311.

‡ Ether dissolves to some extent other constituents present.

meat solids, so that the percentage of total nitrogen gives no absolute information as to the stimulant any more than the nutritive value of the preparation.

The nitrogen was estimated by Kjeldahl's method,* and the results differed only infinitesimally in the case of the same extract.

Differentiation of Total Nitrogen.

Various schemes have been recommended for the differentiation of the total nitrogen. After many trials of every known process, I am forced to the conclusion that beyond a certain point they are all liable to an ever-increasing experimental error as the analysis proceeds, until the results are not to be received with any degree of confidence. What is most desirable to ascertain is the proportion of nitrogen due to the meat bases present, upon which the stimulant value of these preparations depends. But there is no really satisfactory *direct* method of estimating this nitrogen, and the method by remainder is, for reasons already stated, and also owing to their varying percentage of nitrogen very unsatisfactory.† I have not, therefore, attempted to tabulate results of nitrogen differentiation, which cannot be held as scientifically accurate. The nitrogen of albumen, syntonin, albumoses, and gelatine and peptones, is of comparatively little consequence, as these contribute nothing to the stimulating properties of the preparation, while their nutritive power has little to do with the real value of meat extracts.

Two forms of nitrogen present, however, I opine to be worthy of consideration :—

1, Ammoniacal Nitrogen, and 2, Nitrogen of matter insoluble in cold water, and meat fibre. With regard to the first, it has neither stimulant nor nutritive properties, while in the second we have in the proportion due to meat fibre, what may very justly be termed an impurity in the preparation. So far then as these

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* Professor Glaister's Modification, as detailed in his laboratory notes.

† Rubner (Zeit. Biol. for 1884, p. 265), has shown that some at least of the meat bases have no nutritive value. Some of them in excess are actually poisonous. (see also "Animal Alkaloids" by Aitken). Different authorities employ different factors, *e.g.*, Hehner 6·25, Stutzer 3·12, for the estimation of the meat bases from the nitrogen supposed to be derived from them.

two forms of nitrogen are concerned, the results are as follows :—

	Ammoniacal Nitrogen.	Nitrogen of insoluble matter and meat fibre.
Armour's Extract, -	0·357 per cent.	0·248 per cent.
Bovinine, - - -	0·021	none
Bovril, - - - -	0·079	3·045
Liebig's Extract, - -	0·408	2·164
Lipton's Extract, - -	0·391	2·718
Valentine's Meat Juice,	0·185	none
Wyeth's Beef Juice, -	0·244	none

The ammoniacal nitrogen was estimated as in water analysis by diluting a few grams of the preparation with a quantity (500 c.c.) of distilled water in a distillation apparatus, adding a pinch of dry, recently ignited, sodium carbonate, distilling 100 c.c., and Nesslerizing. The process presented no difficulty.

The nitrogen of insoluble matter (including meat fibre), was estimated by diluting a few grams of the preparation with a quantity of distilled water, filtering, washing the precipitate (if any) left on the filter, and estimating the nitrogen in the precipitate by Professor Glaister's modification of Kjeldahl's method. The method was simple, but prolonged washing was necessary.

MICROSCOPIC APPEARANCES.

While at first glance it might seem that little information of any moment could be gained by the microscopic examination of meat extracts, the results appended show that this is not so, and that in some cases the information as to constituents gained by the use of the microscope revealed features which were as interesting as they were at times unexpected. The examination was conducted simply by diluting (if necessary), a minute fraction of the extract with distilled water, and examining at once on an ordinary glass slip. The appearances given are the results of a large number of experiments in each case.

ARMOUR'S EXTRACT OF MEAT.

1. Numerous large and small cubical crystals of sodium chloride.
2. Occasional leguminous starch grains.
3. Amorphous solid matter (not soluble in water).
4. Altered meat fibre showing no striation.
5. Crystals of tyrosin in clusters.
6. No corpuscular elements.

BOVININE. (UNDILUTED.)

1. An almost homogeneous yellowish medium.
2. A few altered red blood corpuscles.
3. Numerous clusters of tyrosin crystals.

BOVRIL.

1. Fairly numerous small crystals of sodium chloride.
2. Unaltered muscular fibre in considerable quantity.
3. Altered corpuscular elements.
4. Cellular vegetable tissue, the cells containing red pigment.
5. Crystals of tyrosin.
6. Fat globules.

LIEBIG'S EXTRACT.

1. Salt crystals, not very numerous.
2. Altered corpuscles.
3. Altered meat fibre in small quantity.

Medium comparatively homogeneous.

LIPTON'S EXTRACT.

1. Salt crystals, large and small.
2. Numerous red and white corpuscles.
3. Altered meat fibre without striation.
4. No tyrosin crystals.

VALENTINE'S MEAT JUICE. (UNDILUTED).

A practically homogenous yellowish menstrum, showing only a very few minute crystals of tyrosin.

WYETH'S BEEF JUICE.

1. Salt crystals, fairly numerous.
2. Leucin.
3. Tyrosin.
4. Altered corpuscular elements.
5. No meat fibre or amorphous matter.

CONCLUSIONS.

Looking at the results as a whole, it may be said at once that the claim of any of the preparations to be a concentrated food is inadmissible. It is quite clear that any proportion of real nutritive matter present is in such small relative proportion as to have little bearing on the question of the value of the preparation as an article of food, properly so called. The inherent value of meat extracts lies in the stimulant power of the meat bases present, and the best test for these is the effect on the animal economy after administration.

Undoubtedly, even as stimulants the preparations vary much in value apart from the proportion of meat bases present. The questions of ease of absorption and absence of insoluble matters are of some moment; moreover, the addition of salt as a preservtive is hurtful, as already pointed out. The liquid preparations without added salt seem best from the absence of insoluble matters and added salt.

The nutritive elements (albumen, peptone, etc.), actually present in such preparations can be supplied, and better supplied outside of meat extracts altogether; but we have no real substitute for the stimulant meat bases. On the latter, then, the true value of meat extracts depends; and while no actual objection can be taken to the presence of nutritive material in these preparations, except that there is apt to be a corresponding diminution in the proportion of meat bases (see page 4), it is evident that their value in dietetics does not depend at all on the proportion of such nutritive matter present, or in other words their real value depends on their stimulant powers as shown by clinical experience.

Attempts have been made, as already pointed out, to increase the nutritive value of meat extracts by *adding* albumen, peptone, and gelatine, to the extract proper, although in the case of gelatine any gain in real nutritive value is doubtful. Following this to a logical conclusion it would be proper, as noted on page 5, also to add fats and carbohydrates in due proportion, so that the so-called "extract" could be recommended to the public as a "perfect food."

Further, any appreciable proportion of gelatine if present *must* be in the form of an addition, as owing to the low temperature at which the modern meat extracts are prepared, the gelatine is not removed from the meat.

The proper place of a meat extract in dietetics is as a stimulant; and the stimulating action is much increased by its being administered diffused in hot water which, is itself a stimulant, so that another function of the extract may be said to be to give sapidity to the hot water which is exhibited along with it. The stimulant effect of extract of meat given in cold water would be very slight.

In the case of the liquid extracts, or so-called "meat juices," it is usually recommended that they be given in cold water; but the argument still holds good, as this recommendation is simply for the sake of appearance, as owing to the exceptional propor-

tion of albumen in these preparations the addition of water much over 180° F. causes precipitation of the albumen and forms a muddy-looking mixture.

Beef tea, made in the usual way, has several advantages over even the meat juices. The source and quality of the meat can be judged of; the flavour is much superior, and the result thus more appetising; preservatives are not required; the mineral salts and meat bases are more thoroughly extracted; and, from the higher temperature employed, much of the collagene of the meat is converted into gelatine and appears in the product.

At the same time meat extracts and juices have an extensive field in actual practice. They may be used largely and safely where rapid stimulation is required, without their giving rise to a craving for over-indulgence.

[I have to acknowledge my great indebtedness to Professor Glaister for many valuable hints during the course of this investigation].

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