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Practical application of the Law pointed out by Dr. R. D. Thomson, *of the proper Balance of the Food in Nutrition. By* Dr. C. REMIGIUS FRESENIUS, *Professor of Chemistry at the Agricultural Institute of Wiesbaden*.*

IN reference to the question concerning the relation which must subsist between the nitrogenous and non-nitrogenous nutritive substances in the food of men and animals, it is but due to Dr. R. D. Thomson to acknowledge, that he considers this the most important circumstance in nutrition, and was the first to call attention to it.

This relation is obviously different in various classes of animals, and besides it must be different even in the same class of animals, according to their mode of life and to the amount of exercise they undergo.

An animal which is hard worked will require a different proportion to one which stands at rest in a stable; still more different must be the proportion when our object is to fatten the animal. I consider it to be one of the most important tasks of dietary and the feeding of cattle, to fix the requisite proportions suited to the various modes of life, for it may be understood that these limits cannot be overstepped on either side without injury.

Let us suppose, for instance, an animal requires under certain circumstances the proportion of 1 nitrogenous (nutritive) to 5 non-nitrogenous (calorifiant) constituents in its food; but if we give it food in which the proportion of 1 to 10 prevails, there will be, in the process of nutrition, for every 1 part nitrogenous only 5 parts non-nitrogenous assimilated; the other half of the non-nitrogenous (calorifiant) aliment will be wasted†.

But it is not the pecuniary loss alone which arises through this, that deserves consideration; for it is clear that the animal will be burdened with the process of getting rid of the unassimilated half; for this object strength is required, which might otherwise have been spared.

If we give it food containing too large a proportion of nitrogenous aliment, in favourable circumstances it will consume

* Translated from the *Lehrbuch der Chemie für Landwirthe, Forstmänner und Cameralisten von* Dr. C. Remigius Fresenius (1847), page 480, by William Augustus Perston.

† The original passage is "So wird es beim Ernährungsprocesse auf je 1 Thl stickstoffhaltige eben doch nur 5 Thle stickstoffreie Besthandtheile verwenden, die andere Hälfte der stickstoffhaltigen Nahrungsmittel wird vergeudet." The true reading it is apprehended ought to be *stickstoffreie Nahrungsmittel*, and it has thus been rendered in the English version.—TRANS.

the dearer instead of the cheaper non-nitrogenous aliment; but in unfavourable circumstances it will become diseased, by being compelled to act in opposition to nature.

Taking it for granted that the requisite proportions for different circumstances were ascertained, the choice of aliment could be regulated on the most rational basis.

[We speak here primarily only of the absolute strength of nourishment, without noticing the greater or less degree of digestibility possessed by equally nutritious substances, and the proportion of unassimilable constituents which they contain.]

We observe, for instance, that cows on a meadow, feeding only upon grass, enjoy good health. Now let us endeavour to ascertain how we can produce the same proportion of non-nitrogenous and nitrogenous aliment with other descriptions of food.

The proportion which exists in grass or hay is 1 to 8·3, as in the following Table:—

	Relation of 1 part nitrogenous to non-nitrogenous.	Relation of 1 part nitrogenous to salts.	The following quantities contain 1 part of nitrogenous matter.			
			Nitrogenous, non-nitrogenous and salts.	Dried at 212°.	Dried in air.	Fresh substances.
	I.	II.	III.	IV.	V.	VI.
French beans	1·81	0·15	2·96	3·45	4·00	
Lentils	1·87	0·09	2·96	3·45	4·00	
Field beans	2·08	0·15	3·23	3·66	4·29	
Peas	2·14	0·11	3·25	3·66	4·28	
Wheat	2·42	0·11	3·53	4·21	4·85	
Oats	4·08	0·24	5·32	6·41	7·35	
Barley	4·25	0·27	5·52	6·53	7·57	
Rye	4·42	0·13	5·55	6·29	7·24	
Red turnips	5·08	0·42	6·50	6·45	......	35·3
Red clover	6·08	0·60	7·68	7·68	9·72	32·0
White turnips	6·39	0·55	7·94	7·91	......	65·1
Indian corn	6·55	0·10	7·65	8·13	9·34	
Mangel-wurzel	7·26	0·44	8·70	8·65	......	48·8
Carrots	7·84	0·55	9·39	9·39	......	67·6
Meadow-grass	8·30	0·73	10·03	10·73	12·47	32·8
Potatoes	9	0·40	10·40	......	......	41·2
Oat-straw	12·5	2·04	15·54	40·00	55·55	
Wheat-straw	14·2	2·48	17·68	40·00	54·05	
Rice	14·8	0·10	15·90	16·61	18·41	
Rye-straw	24·4	1·93	27·33	53·48	65·79	
Barley-straw	29·3	3·08	33·38	52·35	58·82	
Cherries	41·	0·18	42·18	......	......	175·4
Pears	121·6	0·40	123·00	......	......	1250·

This Table, as given by Fresenius, is derived from German authorities, including several results obtained and published by Dr. Thomson in his Researches on Food, p. 167. See also Phil. Mag., vol. xxxii. p. 459. There is therefore some discrepancy when compared with English grain, the German grain being richer in nitrogen. See Dr. Thomson on the Composition of German and English Bread, Phil. Mag. vol. xxiii. p. 321.

Were we then to give them carrots, in which 1 part nitrogenous is contained for every 7·84 parts of non-nitrogenous constituents, the proportion would not be materially disturbed; but were we to give them potatoes (1 : 9), we disturb the proportion somewhat more. It is therefore expedient to feed them with a substance which is richer in nitrogen; this proper proportion may be obtained with exactness by mixing 1 nutritious equivalent of red clover with 3 nutritious equivalents of potatoes:—

$$\begin{aligned} 1 \times 1:6 \quad &= 1: \ 6 \\ 3 \times 1:9{\cdot}00 &= 3:27 \\ \hline & \ \ 4:33 \text{ or } 1:8{\cdot}25. \end{aligned}$$

To produce this mixture, we feed them by giving them 9·7 lbs. of dried clover for every 123·6 lbs. of potatoes.

If we wished to give them the same proportion in white turnips and oat-straw, we must supply for every 2 nutritious equivalents of the former 1 nutritious equivalent of the latter; for this mixture gives the proportion of 1 to 8·4; that is, they must be fed with 130 lbs. of fresh white turnips for every 55·55 lbs. of dried oat-straw.

A horse that works hard requires the proportion of 1 to 4. For this we give him oats which represent that proportion. But if we wished to give him the same proportion in field beans and hay, we must take for every 2 alimentary equivalents of the former 1 alimentary equivalent of hay, for such a mixture has the proportion of 1 to 4·1. We feed him therefore with 8·58 lbs. of dry field beans for every 12·47 lbs. of dry hay.

A man requires for a certain mode of life the proportion of 1 to 3. He wishes to eat beef and potatoes; he must, therefore, for every 2 alimentary equivalents of beef eat 1 alimentary equivalent of potatoes, for this mixture gives the proportion of 1 to 3·01; he must therefore use for every 2 lbs. of boiled beef (reckoned without water) 41 lbs. of potatoes (reckoned in the fresh state).

If he wished to produce the proportion of 1 to 4 with carrots and raw bacon, he will attain it by mixing 5 alimentary equivalents of the former with 6 alimentary equivalents of the latter, which represent the proportion of 1 to 3·99. For this purpose he must eat 338 parts of fresh carrots for every 11 parts of raw bacon (reckoned free from water).

Concerning the question, as to what is the proper quantity of aliment (possessing the due proportions) which is to be given under different circumstances, experience alone can determine it. For the computation, how the necessary quantity may be given in diverse properly assorted alimentary mixtures, we would refer to the divisions III., IV., V. and VI. of the foregoing table.

If a cow requires in twenty-four hours 10 kilogrammes (22·05 lbs. avoirdupois) of air-dried hay, how many kilogrammes of the mixture given above of clover and potatoes would it require to replace it?

10 kilogrammes of air-dried clover contain in all 8·04 kilogrammes (17·728 lbs. avoirdupois) of nutritious matter, for

$$12{\cdot}47 : 10{\cdot}03 = 10 : x$$
$$x = 8{\cdot}04.$$

That mixture will consist of 9·7 kilogrammes (21·38 lbs. avoirdupois) of dry clover, which contain in all 7·68 kilogrammes (16·93 lbs.) of nutritious matter and 123·6 kilogrammes (272·5 lbs.) of potatoes, which contain in all 31·20 kilogrammes (68·79 lbs.) of nutritious matter.

133·3 kilogrammes (293·93 lbs.) of the mixture contain accordingly 38·88 kilogrammes (85·72 lbs.) of nutritious matter.

38·88 kilogrammes (85·72 lbs.) of the joint nutritious matters are equal to 133·3 kilogrammes (293·93 lbs.) of the mixture. How many are 8·04 equal to? $x = 27{\cdot}5$ (60·63 lbs.).

27·5 kilogrammes (60·63 lbs.) of the mixture in question are equivalent to 10 kilogrammes (22·05 lbs.) of hay in the proportion and quantity of nitrogenous and non-nitrogenous alimentary substances. In a precisely similar manner the kind and quantity of the salts must be attended to in practice.

Conclusions from the foregoing.

We have approximated much more closely to the object we had in view, viz. a completely rational system of nutrition, than it has hitherto been possible to do, and can answer the proposed questions with perfectly accurate average numbers; and we have now only duly to consider the influence which the unappropriated portions of food exert on the body (the getting rid of them involves a waste of strength); and further, the greater or less degree of digestibility (*der leichteren oder schwereren, schnelleren oder langsameren Verdaulichkeit*) of each species of aliment, in order to do it with perfect precision.

But we can even now, from what has already been stated, educe safe and weighty conclusions, namely the following:—

1. It is an impossibility to sustain either a man or a beast on food entirely devoid of nitrogen, however great in quantity it may be.

2. All that has been said in the older as well as in many of the newer books on husbandry, respecting the relative nutritive value of different kinds of forage, cannot, inasmuch as it

was not arrived at by experience, but deduced from theoretical views, possibly be correct, because these views do not accord with facts.

3. The discovery of the true relative value of aliment, and of the proportion in which it may be replaced, may be ascertained without much difficulty, so long as chemists and farmers work hand in hand for the exact solution of the above questions.

4. A completely rational system of nutrition, that is such an one as combines the greatest amount of strength with the least consumption of nourishment, will then be possible.

5. A loss of nutritious matter and of strength often takes place where it would be least expected, namely by the consumption of all kinds of food (or forage) where the due proportion between nitrogenous and non-nitrogenous constituents does not exist, say by eating only fruit or potatoes.

6. It can with safety be decided by the above under what circumstances substitutes for bread may be employed, and what is their respective value for each desired proportion.

Raw and cooked Articles of Food.

Many kinds of food cannot be eaten raw by man; others, although they may be eaten raw, agree much better with us when cooked.

Hence boiling, roasting, baking, &c. has a twofold effect; primarily, it converts indigestible or food difficult of digestion into a digestible or more easily digestible condition. Thus, starch is converted into gelatinous starch, into dextrine or sugar; cartilaginous substances into glue; and chondrine, fibrine, into changed fibrine, &c. Secondly, it frequently confers upon them an agreeable taste.

But can the real nutritive value of food be augmented by cooking? Impossible! Still it may be of the greatest benefit in feeding cattle to cook their food. The advantage accrues in this way: that potatoes, turnips, &c. are more quickly and more easily digested when boiled than raw; and thus there is much less chance for any portion to be thrown off in an undigested state (unassimilated). Its warmth gives also a slight advantage to cooked food; it deprives the body of no heat; and the non-nitrogenous substances, which in the cold food would have been required to afford heat, can be used for the production of fat. But whether cold or warm food is to be preferred in a practical point of view cannot from all this be conclusively deduced. It is a question only to be answered by experience, for the result is entirely dependent on the nature and requirements of the animal.