The feeding of animals for the production of meat, milk, and manure, and for the exercise of force

INTRODUCTION AND HISTORY

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It was shown in the last section (V) on the rotation of crops that any explanation of the benefits of rotation is quite inadequate which does not take into account the results of the feeding of animals on the farm. Thus in the discussion of the amounts of the produce of the various crops grown in alternation with one another, and of the amounts of the various constituents of the individual crops, or of their separate parts, it was pointed out that only certain portions of them were at once available as salable products ; a large proportion remaining for use on the farm in some way, and only eventually yielding a profitable return.

The extent to which the retention on the farm of the constituents accumulated in the crops may take place may usefully be illustrated by reference to a particular example, which will convey a clearer conception of the subject than any mere general statement can do. Accordingly, in Table 66 is given an approximate estimate of the proportion of certain selected constituents of the crops grown in the typical four-course rotation of Swedish turnips, barley, leguminous crop, and wheat, which will be at once sold off the farm, and of the amounts retained upon it ; supposing that only the grain of the cereals is sold, and that the root crop, the leguminous crop, and the straw of the cereals are retained for farther use. The estimates are founded on the average amounts of produce obtained over eight courses in the fully manured rotation, the particulars of which were given and discussed in the section on rotation above referred to.

TABLE 66.—*Illustration of the proportion of the constituents of crops grown in rotation at once sold off the farm, and of those retained upon it for further use*

	Per cent of total in the crops	
	At once sold off the farm.	Retained on the farm for further use.
	Per cent.	Per cent.
Dry matter	30.6	69 4
Nitrogen	43.4	56.6
Total mineral matter (ash)	14.5	85.5
Phosphoric acid	56.2	43.8
Potash	20	80

It is true that the exact figures given in the table have only reference to a particular case, and that in practice there will sometimes be larger and sometimes smaller proportions of these constituents of the crops at once sold or retained on the farm. Nevertheless, the illustrations may be taken as essentially typical, and as so far conveying a very useful impression on the subject.

Referring to the figures, the question arises. To what beneficial or profitable purposes are about two-thirds of the total vegetable substance grown—more than half its nitrogen, nearly half its phosphoric acid and about four-fifths of its potash—retained on the farm ? Briefly stated, it is for the feeding of animals for the production of meat, milk and manure, and for the exercise of force, that is, for their labor. It is, then, the facts and the principles involved in the feeding of the animals of the farm for these various purposes that we have now to consider.

It is obvious that so long as a country is only sparsely populated, and the needs of the people are amply supplied under a comparatively rude system of agriculture, in which extended area precludes the necessity for improved methods, there would be little, either of scope or of inducement, to study economy in the feeding of animals or to systematic practice in regard to it. But as population increases in proportion to area, there arises the necessity for increased production over a given area. It has already been pointed out in section V on rotation that, in our own country, gradually a greater variety of crops came to be grown ; that first leguminous crops and then root crops were introduced, and finally the system of rotation became general. Thus, a much greater variety and a much greater quantity of home-produced stock foods became available, and in time foods of various kinds were imported from other countries.

Somewhat similar changes in their food ressources occured in various parts of the continent of Europe ; and, with these, came the inducement, if not the necessity, to pay more attention to the subject of feeding. The end was however, sought to be attained by somewhat characteristically different methods in our own country and on the continent. With us, more special attention was paid to the improvement of the breeds of the farm animals themselves, not only to enhance the development of the most valuable characters in the final product, but to secure early maturity, and thus materially to economize the expenditure of food in the mere maintenance of the living meat-and-manure-making machine. As to the use and adaption of different foods, but little systematic inquiry was undertaken in regard to it, each feeder relying largely on his own judgment, or on the unwritten rules adopted in his locality as the result of practical experience.

On the Continent, however, and especially in Germany, much more attention was paid to the character of the food than to that of the animal, and toward the end of the last century and the beginning of this much was devoted to determining the comparative values of different foods, and tables were constructed in which, adopting hay as the standard, it was attempted to arrange all other foods according to their supposed value compared with that standard. The plan was to give the amount of each food which it was estimated was equivalent in food-value to 100 parts of hay.

The first comprehensive tables of "hay values" were constructed by Thaer, and were published by him in 1809. His operations, experiments, and writings were of an essentially practical character. His estimates of so-called "hay values" seem, however, to have been based to some extent on the determinations of the supposed nutritive contents of different foods which had been made by Einhof, but partly, also, on his own determinations, and partly on direct feeding experiments. In these he ought to ascertain how much of the respective foods was required to substitute a given quantity of hay in the daily ration of the animals. His estimates were, at any rate, controlled by such experiments, and he states that their results, upon the whole, tended to confirm the conclusions arrived at by analysis.

Other writers also published tables of hay values, or hay equivalents of foods. In some of these the results of new experiments, sometimes analytical and sometimes practical, were embodied ; but it is obvious from the identity of the figures in many cases that they were largely compilations, one from another.

Such was the condition of knowledge on the subject when Boussingault commenced his investigation of it, soon after 1830. Like Thaer, Boussingault had the advantage of being a practical agriculturist, but while Thaer looked at the question of the feeding of the animals of the farm almost exclusively from the pratical point of view, Boussingault approached it mainly from that of the chemist and the physiologist ; though he, at the same time, made direct experiments with farm animals, and so arranged and conducted them as not only to elucidate some points of special scientific interest, but also to afford data which might serve both for the explanation and for the improvement of agricultural practice.

Thus, besides contributing much toward a better knowledge of the actual and comparative value of different foods, he investigated the question whether animals either availed themselves of the free nitrogen of the air as a source of some of their nitrogen, or eliminated either free or combined nitrogen by the lungs or skin ; also whether the fat stored up by the fattening animal was exclusively derived from the already formed fat of the food, or whether it was produced within the body, from other constituents of the food.

From the point of view of the practical agriculturist, Boussingault seems fully to have assumed the utility of attempting to arrange stock foods according to their nutritive value compared with that of hay as a standard ; and, in fact, this idea has given a direction to much subsequent investigation also.

The first great advance made by Boussingault was, however, to determine the nitrogen in a large number of different foods ; and taking the amount of it as for the time the best measure of nutritive value, on this basis to compare them with hay. That is to say — supposing 100 parts of average good hay to contain a certain amount of nitrogen, how much of each of the other foods would be required to supply the same amount of it. These amounts would, on the supposition adopted, represent the quantities by weight in which one food may be substituted for another, and they may be considered as the theoretical equivalents of 100 of hay. Accordingly he determined the nitrogen in about seventy-six different descriptions of food, which at that date involved a truly enormous amount of labor.

Further, he selected a few typical articles of food for comparative feeding experiments, so as to be able to compare the results obtained both with those indicated by theory according to their contents of nitrogen, and with the estimates of others founded chiefly on somewhat similar practical trials. He fully recognized the difficulties and uncertainties of such modes of experimenting and took great care to obviate error arising from them. He discussed the general results of some