Animal Species That Feed Mankind: The Role of Nutrition

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IN considering the species that feed mankind, it is important to understand how improved feeding practices for animals can contribute to the better nutrition of our increasing population. Insofar as animals consume food that might be eaten by man or products obtained from land that could be used to produce food for man, there is a great waste of food resources as measured in calories.

About 20 percent of the gross energy (calories) fed to a pig, the most efficient converter among farm animals, is returned in edible products for man's use. The dairy cow is three-quarters as efficient as the pig on this basis, but other animals rank much lower. For steers and lambs, the conversion figure is only about 4 percent. These facts explain why an animal industry tends to become smaller as the struggle to get enough food to fill the stomach, whatever the kind, becomes greater. As this happens, the diet becomes poorer in nutritional quality, and malnutrition increases accordingly. This is because the dietary value of animal products lies primarily in the high-quality protein, minerals, and vitamins supplied and not in their calory contribution.

Recent research, especially that dealing with the discovery of new vitamins, has served to emphasize the importance of the nutrients for which animal products are rich sources. As a supplement to the cereal diets that comprise 70 percent or more of the total food of the majority of the world's population, animal products have a special importance in supplying nutrients that are otherwise likely to be deficient, even though calory intake is adequate.

The production of animal products for man's use thus has a large significance in terms of his nutrition and health. Where population presses on the food supply, the goal of animal feeding must be to provide maximum production of the nutrients that man especially needs to supplement a cereal diet, with a minimum waste of the potential food resources as measured in calories. Animal species differ in efficiency in this respect.

Some years ago I made a study of published experimental data to determine how various species differ in the efficiency of production of nutrients per gross calory of feed consumed (*1*). In the preparation of the present paper (*2*), the results were checked with more recent data. The following generalizations seem justified.

Pigs, dairy cows, laying hens, and broilers are much more efficient in protein production than are steers or lambs. The dairy cow produces 10 times as much calcium as does its nearest competitor, the hen, and also ranks ahead of all others in riboflavin production. The hen ranks first in vitamin-A production, followed by the dairy cow, while the other species do not produce significant amounts. The pig ranks first in thiamine, the broiler in niacin.

The steer and lamb show a low efficiency in the production of all nutrients on a gross energy-intake basis. The primary reason for this is that their rations are of much lower digestibility because of the large amounts of roughage consumed. This is food that man cannot eat, and thus figures based on gross energy without regard to source markedly overstate the waste by ruminants of man's food supply.

This fact is illustrated in Table 1, containing data from Jennings (*3*). This table shows the number of "feed units" required by the various species to produce man's daily calory requirement. The "feed unit" used here was chosen to represent the common denominator of all kinds of feed and to equal the feed value of 1 lb of average corn. The "All feed" column reveals the same order of efficiency calculated for the conversion of gross calories of feed and the edible calories of production. Our interest lies in the "Concentrates" column, however, which shows the requirements for concentrates that otherwise could be used directly by man. On this basis, the dairy cow, which requires only one-quarter of its total feed as concentrates, is much more efficient than the pig, which excels on an "all feed" basis. The lamb, which is the least efficient on the latter basis, also goes ahead of the pig when concentrates only are considered. The beef animal also makes a relatively much better showing when concentrates alone are considered, whereas poultry depends almost entirely on concentrates and, therefore, is the least efficient.

This comparison is faulty, of course, when the

Table 1. "Feed units" required to produce 2600 kcal of human food.

Animal product	All feed (lb)	Concentrates (lb)
Pork	7.7	7.2
Milk (dairy cows)	9.3	2.3
Eggs	21.9	20.6
Poultry meat	29.9	27.1
Beef	71.6	15.2
Lamb	74.5	4.7

coarse fodder comes from land that otherwise might grow food for direct human consumption. This is true in the United States. However, ruminants do consume large amounts of straw and other by-products of human food production and also grass from land which, because of its scanty rainfall or topography, cannot be effectively cropped. Thus, cows and sheep can produce high quality human food from some areas where otherwise no food at all would be obtained. Pigs and poultry compete directly with man for most of their food supply. Where only a few per farm are kept, however, and they consume products otherwise wasted, such as cull fruits, vegetables and seeds, kitchen wastes, and worms and insects, little competition with man's food results.

There are other factors, such as maintenance of soil fertility, production of nonfood products, and production per unit of land labor, that govern the efficiency of animals as contributors to man's food supply. The purpose of this brief discussion is to show the major factors that must be taken into account in considering, on an economic and nutritional basis, how animals can contribute to man's food supply and in deciding which species can make the greatest contribution in a given situation.

All species are more efficient today than they were a decade or more ago, because of the application of the findings of nutrition research. With respect to hogs and poultry, the recognition that protein nutrition depends on the kinds and amounts of the amino acids supplied and studies of amino acid requirements and their distribution in feeds have resulted in feeding practices that result in greater production at lower feed costs. While some 22 amino acids are required to build body protein, only 10 are essential as such to nonruminants. The others can be manufactured in the body, provided that a nonspecific source of nitrogen, such as amides or ammonium salts, which can furnish amino groups, is available. This recent discovery may prove to be of great practical importance in lessening the need for protein as such. The specific knowledge that has developed regarding amino acid requirements and content in feeds also provides the opportunity for effectively using specific key amino acids which the chemical industry may produce inexpensively for the purpose. The discovery of vitamin B_{12} as a growth factor for pigs and chickens has resulted in the replacement of animal protein feeds by vegetable protein sources plus B_{12} and a more economic use of feed accordingly.

The latest development in the feeding of pigs and chickens has resulted from the finding that antibiotics in small amounts are growth factors for these species. Antibiotics are drugs, not feeds. They do not supply nutrients, but in some way they promote feed consumption and intestinal conditions that result in a marked improvement in growth, particularly in the early weeks. They bring animals to market weight more quickly and with less total feed. The improvement in growth rate to market is of the order of 5 to 20 percent, depending on the species and on various conditions, with a saving of some 2 to 10 percent of feed. Sources of antibiotics for this purpose are readily available at low cost and are in wide use. Here it should be pointed out that their principal value is in stimulating early growth. They have no demonstrated value for reproduction or for milk or egg production.

As an example of what these developments have meant in the case of poultry, the data in Table 2 are cited. The data for 1932 are taken from a study by Heuser and Andrews (*4*), and those for 1951, from Potter and Ringrose (*5*). Being experiment station data, they reflect a better-than-average commercial performance for both periods, but they do present a fair picture for comparative purposes. These data show that today chicks can reach a 60-percent greater weight at 12 wk than they did 20 yr ago, with 27 percent less feed per pound gain. The birds that required 12 wk to attain a weight of 2.5 lb in 1932 can now reach this weight in 9 wk. In 1932, 16 wk were required to bring a broiler to a market weight of 3.5 lb. Today this is being done in 10 to 11 wk, at a large saving in feed costs. Obviously there are also important savings in labor and more efficient use of equipment.

The breeds used in these two studies were not strictly comparable, but in both cases they were the heavy breeds used in commercial broiler production. Clearly, improvements in breeding and in management, as well as in nutrition, have played a role in the advances shown in Table 2. In citing these recent accomplishments, it should also be pointed out that current research gives high promise of further advances to come. A very promising field deals with the role of microorganisms in the intestine and their influence on nutrition and health, particularly as related to the nature of the diet. There is also clear evidence that some vitamins of practical importance remain to be identified.

With respect to cattle and sheep, studies of rumen functions have resulted in marked advances in improving the efficiency of feed utilization. The rumen is a big fermentation vat in which microorganisms break down the cellulose and other higher carbohydrates to metabolically useful compounds; this process enables cattle and sheep to depend to a large extent on roughage for their food. A better understanding of the biochemical and microbiological factors is resulting in

Table 2. Growth rate and feed conversion figures for chickens, 1932 vs. 1951.

Weeks	Body weight (lb)		Feed conversion (lb feed/lb weight)	
	1932	1951	1932	1951
2	0.18	0.37	1.61	1.26
4	.44	.91	2.22	1.81
6	.89	1.51	2.56	2.24
8	1.42	2.35	2.91	2.43
10	1.84	3.26	3.52	2.67
12	2.47	3.99	3.73	2.95

feeding practices that make greater use of forage and thereby lead to more economical production than has heretofore been possible.

In the rumen, bacteria also synthesize amino acids to a degree that makes the protein nutrition of the animal independent of the amino acid makeup of the feed. Amides, such as urea, and ammonium salts can be used for this purpose, thus providing building stones for all the amino acids required by the body; this is in contrast to the needs of nonruminants, whose feed must contain some 10 amino acids. Experiments have shown that sheep can build body protein with urea as the sole source of nitrogen. Urea can replace a part of the protein in the feed of ruminants without loss of production; during World War II it was widely used for this purpose. Research now in progress may be expected to show us how to make more extensive and more effective use of nonprotein-nitrogen compounds manufactured by the chemical industry. In this way, a large contribution can be made to man's food supply by freeing for his own use protein sources now consumed by ruminants.

It is recognized that both the efficiency and the extent of carbohydrate breakdown and of protein synthesis in the rumen depend on various factors that govern the microbiological flora and their activity. Bacteria require many growth factors, some undoubtedly as yet undiscovered. The study of the nutrition of bacteria, particularly in connection with rumen activity, is thus a very important field in the interest of man's food. This is the area of research on which biochemists, microbiologists, and nutrition scientists are now concentrating, to produce findings leading to more efficient milk and meat production. This field of research has practical value for the better nutrition of peoples in areas where the possibility of any significant animal industry is not justifiable unless it utilizes plant products that man cannot digest or grazing land that cannot be cropped, and also does not compete with man for protein.

A development of special significance with respect to grazing animals is the recognition of their need for trace elements which are frequently lacking in the soil and thus in the forage grown thereon. A daily intake of the amount of cobalt which could be held on the head of a pin makes the difference between life and death in a sheep. A correspondingly small amount is essential for cattle. Before this fact was known, many thousands of grazing animals died annually throughout the world, and areas were abandoned because they would not support an animal industry. Today the needed cobalt is supplied, and animal production has been greatly stepped up accordingly. The story is similar for copper. Further advances can confidently be expected from trace-element studies, in identifying additional areas deficient in those elements known to be important and in discovering other elements that may be necessary for grazing animals.

For various reasons, it is not possible to appraise quantitatively the effects of improved feeding practices for sheep and cattle as clearly as can be done for poultry and hogs, but there are data to show that important advances have been made. For example, the records of Dairy Herd Improvement Associations in New York State indicate that average yields were more than 20 percent higher in 1951 than in 1935 and were obtained with 7 percent less feed per unit of milk produced. Here again, better breeding and management have played a role.

The preceding discussion of the special nutritive values of animal products naturally raises the question of whether these values are affected by the nature of the ration, and of the possibilities of improving the nutritional quality, as well as the yields, of these products through better feeding practices. The idea has been promoted by some popular writers and others that feeds from poor soils, whether forage or concentrates, result in the production of milk, meat, and eggs of poor nutritional quality. In general, this is not true. Feeds that are inadequate in amount or quality affect the yield, and not the quality, of the product. There are some exceptions to this general statement, notably the vitamin-A value of eggs and milk, but from the standpoint of my general topic it should be emphasized that the contributions of better animal feeding practices to man's nutrition lie primarily in increasing yields of the products. It is not to be expected that marked improvement can be made in their high nutritive value. This can be counted upon, whatever the feeding system.

In the first part of this paper I discussed the problem of providing the animal products needed for the nutrition of our increasing population in view of the competition involved for basic food resources. I have in turn discussed how this problem is being met by research developments that are greatly increasing the feed efficiency of animal production and enabling animals to draw more and more on feed resources not suitable for man's direct use. It seems probable that the developments to date may represent only a beginning in the advances that may be expected in the feeding of animals, in turn to feed mankind. Meanwhile, there is a large opportunity for a much more widespread application of the discoveries already made.

References

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