



# FEEDS vs. FOODS

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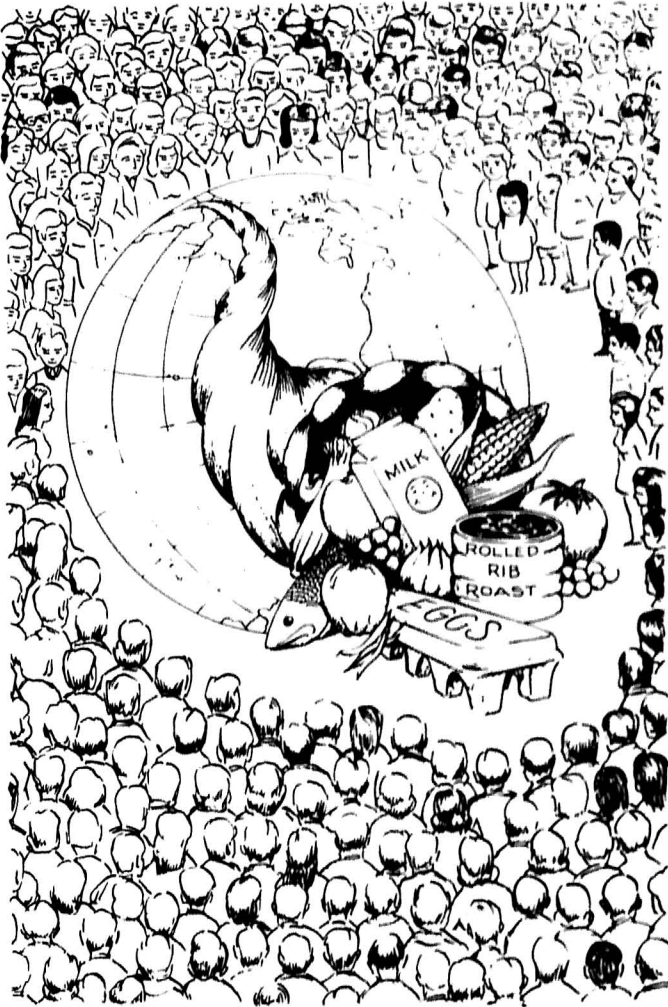


Fig. 1. The horn of plenty. What it's all about.

### Acknowledgement

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# FEEDS VS. FOODS

by

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Back of animals are feeds; and back of feeds are soil resources, spring rains, and the energy of the sun. With the aid of science, technology, and animals, farmers and ranchers combine these to produce a tasty platter of meat and eggs for the table, cream for the peaches, butter for the biscuits, and cheese for the macaroni—all derived from the sun through the process known as photosynthesis.

## All Flesh Is Grass!

Life on earth is dependent upon photosynthesis. Without it, there would be no oxygen, no plants, no feed, no food, no animals, and no people.

As fossil fuels (coal, oil, shale, and petroleum)—the stored photosynthates of previous millennia—become exhausted, the biblical statement, "all flesh is grass" (Isaiah 40:6), comes alive again. The focus is on photosynthesis. Plants, using solar energy, are by far the most important, and the only renewable, energy-producing method;<sup>1</sup> the only basic food-manufacturing process in the world; and the only major source of oxygen in the earth's atmosphere. Even the chemical and electrical energy used in the brain cells of man are the products of sunlight and the chlorophyll of green plants. Thus, in an era of world food shortages, it is inevitable that the entrapment of solar energy through photosynthesis will, in the long run, prove more valuable than all the underground fossil fuels—for when the latter are gone, they are gone forever.

## Photosynthesis

*Photosynthesis is the process by which the chlorophyll-containing cells in green plants capture the energy of the sun and convert it into chemical energy; it's the process through which plants synthesize and store organic compounds, especially carbohydrates, from inorganic compounds—carbon dioxide, water, and minerals, with the simultaneous release of oxygen.*

For many centuries the "humus theory" prevailed; scholars believed that green plants derived all their nourishment from the organic materials of the soil. Finally, in about 1630, Jean van Helmont, a Belgian physician, performed a revealing experiment which proved this belief false. He placed exactly 200 lb of completely dried soil into a vessel; planted a 5-lb

<sup>1</sup>Certain types of microorganisms, termed chemoautotrophs, get their energy from inorganic compounds, but aside from this minor exception, the energy that runs the life support systems of the biosphere comes from photosynthesis.

converted into carbohydrates, fats, and proteins—the three main groups of organic materials of living matter.

Photosynthesis is a series of many complex chemical reactions, involving the following two stages.:

**Stage 1**—The water molecule ( $H_2O$ ) is split into hydrogen (H) and oxygen (O); and oxygen, the necessary gas for breathing of animals, is released into the atmosphere. Hydrogen is combined with certain organic compounds to keep it available for use in the second step of photosynthesis. Chlorophyll and light are involved in this stage.

**Stage 2**—Carbon dioxide ( $CO_2$ ) combines with the released hydrogen to form the simple sugars (glucose) and water. This reaction is energized (powered) by ATP (adenosine triphosphate), a stored source of energy. Neither chlorophyll nor light is involved in this stage.

The process of photosynthesis is depicted in Fig. 2.

The chemical reactions through which chlorophyll converts the energy of solar light to energy in organic compounds is one of nature's best-kept secrets. Man has not been able to unlock it, as he has so many of life's other processes. Moreover, photosynthesis is limited to plants; animals store energy in their products—meat, milk, and eggs—but they must depend upon plants to manufacture it. Additional facts pertinent to an understanding of photosynthesis follow:

1. During the earth's very long geological past, green plants, growing in warm climates in the presence of more carbon dioxide than the atmosphere now contains, grew faster than they were consumed. As a result, vast quantities of carbon, in the form of organic matter now represented by the fossil fuels (coal, oil, shale, and petroleum), accumulated beneath the earth's surface. The combustion of these fuels provides much of the energy now used in homes, factories, and transportation.

2. Photosynthesis is an energy-requiring process, which uses light as the source of energy. Hence, it can occur only when light shines upon green plant tissues.

3. Plant species and genetics (the inherited set of directions) determine whether or not a plant will form high or low levels of specific proteins, carbohydrates, minerals, vitamins, etc. For example, alfalfa always contains more calcium than corn even though they grow side by side.

4. Environmental factors—including the amount of sunlight, the temperature of the air and of the soil, the humidity of the air, and the moisture content of the soil—may also have an important bearing on the concentration of nutrients in a plant. The impact of environmental factors on plant nutrients is of concern to the stockman and nutritionist, as evidenced by the following examples: (a) The amount of vitamin C in a ripening tomato is primarily controlled by the amount of sunlight that strikes the tomato; (b) during cool, cloudy weather some grasses may accumulate high levels of nitrate; and (c) the effects of environment on plant composition may be so pronounced that certain nutritional diseases of animals occur much more frequently in some years than in others, even on the same pastures.

5. Physiological factors of plants—health, maturity, and whether or not the plant is a flower—also exert an effect on the rate of photosynthesis.

From the above, it is apparent that the concentration in plants of the different nutrients required by animals and man is controlled by several processes that depend on the fertility of the soil, the genetics of the plant, and the environment in which it grows. Any one of these factors may affect the level of different essential nutrients or of toxic substances in feeds and foods.

Although photosynthesis is vital to life itself, it is very inefficient in capturing the potentially available energy. Of the energy that leaves the sun in a path toward the earth, only about half ever reaches the ground. The other half is absorbed or reflected in the atmosphere. Most of that which reaches the ground is dissipated immediately as heat or is used to evaporate water in another important process for making life possible. Only about 2% of the earthbound energy from the sun actually reaches green plants, and only half of this amount (1%) is transformed by photosynthesis to energy storage in organic compounds. Moreover, only 5% of this plant-captured energy is fixed in a form suitable as food for man.

With such a small portion of the potentially useful solar energy actually being used to form plant tissue, it would appear that some better understanding of the action of chlorophyll should make it possible to increase the effectiveness of the process. Three approaches are suggested: (1) increasing the amount of photosynthesis on earth, (2) manipulating plants for increased efficiency of solar energy conversion, and (3) converting a greater percentage of total energy fixed as chemical energy in plants (the other 95%) into a form available to man. Ruminants are the solution to the latter approach; they can convert energy from such humanly inedible plant materials as grass, cornstalks, and straw into food for humans. Also, it is noteworthy that animals do not require fuel to graze the land and recover the energy that is stored in the grass. Moreover, they are completely recyclable; they produce a new crop each year and perpetuate themselves through their offspring. It would appear, therefore, that there is more potential for solving the future food problems of the world by manipulating plants for increased solar energy conversion and by using ruminants to make more plant energy available to man than from all the genetic and cultural methods combined.

## **Conserve Energy**

Population growth and food production technology are now creating feed, food, and energy stresses of unprecedented scale and urgency—threatening man's very existence. It's a case of too many people nibbling away at natural resources faster than the earth can combine the energy of the sun, the rains of the heavens, and the minerals of the soil, to produce food.

If the entire world were suddenly to adopt American farming and food processing methods, increasing the diets of all four billion people to the American level, the energy consumed would exhaust the world's known petroleum reserves in 13 years.

Fossil fuels are like a bank account. There is nothing wrong with



*Fig. 3. Ruminants—cattle, sheep, and goats—convert the photosynthetic energy derived from solar energy and stored in grass into food for humans. (Courtesy, The Progressive Farmer, Birmingham, Ala.)*

drawing upon either of them, but neither is inexhaustible. It is highly imprudent not to be aware of big withdrawals and not to cover them. Within a short span of a few years, the world made the transition from a positive energy balance based upon the capture of the energy of the sun via green plants, crops, and forests to an imbalance, or even a negative balance, by resorting primarily to the bank of trapped sun energy of fossil fuels that had accumulated over millions of years.

Modern, mechanized feed and food production requires an extra input of fuel, which is mostly of fossil origin. This auxiliary energy is expended in endless ways to improve agricultural productivity; it is used for drainage and irrigation, clearing of forest land, seedbed preparation, weed and pest control, fertilization, and efficient harvesting. In addition to production as such, there are 2 other important steps in the feed-food line as it moves from the producer to the consumer; namely, processing and marketing, both of which require higher energy inputs than to produce the food on the farm. In 1970, U.S. farms expended an average of 2.5 calories on the farm per calorie of food grown. By contrast, the Chinese wet rice peasant, using animal power (water buffalo), expends only 1 calorie of energy to produce each 50 calories of food.

And that's not all! In 1970, to process the food in the United States required an additional input of 4.1 calories per calorie of food produced, and to market it took another 4.0 calories, making a total input of 10.6 calories (mostly fossil fuels) for each calorie of food produced.

Modern intensive farming has markedly increased crop yields per acre and per man-hour—by as much as 50- to 100-fold. But this has been



*Fig. 4. An Oriental wet rice peasant, using animal power (water buffalo), expends only 1 calorie of energy to produce each 50 calories of food. By comparison, the average U.S. farmer, using mechanical power (tractors), expends 2.5 calories of fuel energy to produce 1 calorie of food. (Courtesy, International Bank for Reconstruction and Development, Washington, D.C.)*

done at the cost of large inputs of fuel. Today, for a surprising number of cropping systems, a 10- to 50-fold increase in the energy output merely doubles or triples the food energy. Thus, the law of diminishing returns prevails.

Scarce and high-priced fossil fuels have spurred a search for conserving stored energy and for increased energy production through photosynthesis. Higher productivity of the agriculture of tomorrow must be achieved through ingenious approaches in order to reverse the present lopsided energy balance. In obtaining increased feed and food yields, we must consider how many calories of energy are required to produce each calorie of feed or food. We must remember that photosynthesis does not deplete fossil fuels. We must remember, too, that grazing animals do not require fuel outside of their own body use to harvest the energy and other nutrients of grass (solar energy converted into chemical energy by grass), a renewable source. It follows that ruminants, which utilize grazing land, offer the best means of stepping up and storing energy for man.

Energy may also be conserved by lessening waste. Pests cause an estimated 30 percent annual loss in the worldwide potential production of crops, livestock, and forests.<sup>2</sup> Every part of our feed, food, and fiber supply is vulnerable to pest attack, including marine life, wild and

<sup>2</sup>Ennis, Jr., W. B., W. M. Dowler, and W. Klassen, "Crop Production to Increase Food Supplies," *Science*, Vol. 188, No. 4188, May 9, 1975, pp. 593-598.

domestic animals, field crops, horticultural crops, and wild plants. Obviously, reducing these losses would conserve energy and increase the supply of feed, food, and fiber.

## Animal Agriculture

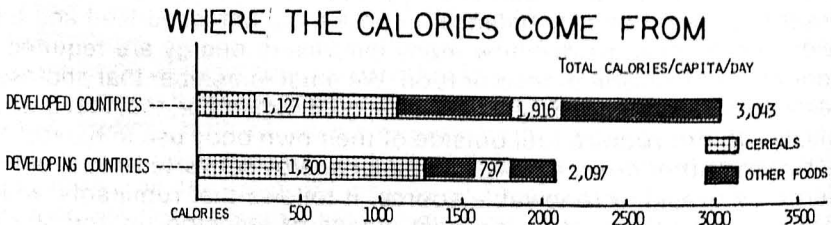
As the ghost of hunger, foretold by the English clergyman, Thomas Robert Malthus in 1798, stalks the world, the focus is on animals. During periods of food scarcity, it is inevitable that some will suggest that grain be diverted from livestock and poultry feeding—that they will challenge the efficiency of animals in converting feed to food and the place of animals in the economical production of human food. Animal agriculture will be on trial. Increasingly, the charge will be made that much of the world goes hungry because of the substitution of meat, milk, and eggs for direct grain consumption.

A response to this accusation requires that animal agriculturalists substitute knowledge for moral indignation. To this end, the important sections that follow are presented.

## Who Shall Eat?

Cereal grain is the most important single component of the world's food supply, accounting for between 30 and 70 percent of the food produced in all world regions. It is the major, and sometimes almost exclusive, source of food for many of the world's poorest people, supplying 60 to 75 percent of the total calories many of them consume (see Fig. 5). However, in many developed countries, more grain is fed to animals than is consumed directly by humans. Under such circumstances; sporadic food shortages and famine in different parts of the world give rise to the following recurring questions:

1. Who should eat grain—people or animals? Shall we have food or feed?
2. Can we have both food and feed?



*Fig. 5. Calories per person per day from cereals vs other foods. In the developed countries, little more than one-third of the calories comes from direct consumption of cereals, compared with about 62% in developing countries. (Based on data from The World Food Situation and Prospects to 1985, Economic Research Service, USDA, Dec. 1974, p. 49).*



## Favoring Bread Alone

Historically, the people of new and sparsely populated countries have been meat eaters, whereas the people of the older and more densely populated areas have been vegetarians. The latter group has been forced to eliminate most animals and to consume plants and grains directly in an effort to avoid famine.

Among the arguments sometimes advanced by those who favor bread alone—the direct human consumption of grain—are the following:

1. *More people can be fed.* Forgetting for a moment the high nutritive value of meats, milk, and eggs, there can be no question that more hunger can be alleviated with a given quantity of grain by completely eliminating animals. About 2,000 pounds of concentrates (mostly grain) must be supplied to livestock in order to produce enough meat and other livestock products to support a man for a year, whereas 400 pounds of grain (corn, wheat, rice, soybeans, etc.) eaten directly will support a man for the same period of time. Thus, a given quantity of grain eaten directly will feed 5 times as many people as it will if it is first fed to livestock and then is eaten indirectly by humans in the form of livestock products. This inefficiency is the result of unavoidable nutrient losses in all animal feeding and the fact that no return is received from that portion of the animal's feed which goes for maintenance (which amounts to approximately 1/2). This is precisely the reason why the people of the Orient have become vegetarians.

2. *On a feed, calorie, or protein conversion basis, it's not efficient to feed grain to animals and then to consume the livestock products.* This fact is pointed up in Table 1<sup>3</sup> and in Figs. 6, 7, and 8.

Thus, in the developing countries, where the population explosion is greatest, virtually all grain is eaten directly by people; precious little of it is converted to animal products.

As people become more affluent, they actually use more grain, but most of it is converted into animal products, for they consume more meat, milk, and eggs. It is noteworthy, too, that no nation appears to have reached such a level of affluency that its per capita grain requirement has stopped rising.

## Favoring Animals

Animals are the main sources of agricultural power, quality proteins and other needed nutrients, and manure in many parts of the world, especially in the more populous and developing countries. They will continue to fill these roles for many years to come.

The Green Revolution gave many of the people of the developing countries enough rice and wheat—carbohydrates. But, for the most part, they must rely on animals (1) to provide needed power, (2) to manufacture

<sup>3</sup>It could be argued that Table 1 makes no provision for the feed used by the sires and dams of these animals—the animals that gave birth to these producers. Others may be critical of using a yearling steer without making provision to get him to the feedlot stage. Finally, it may be contended that any such comparison should be between animals of like age; for example, between broilers and veal calves. Having raised these questions, the authors submit Table 1, which in their judgment is as fair a rating on feed to food efficiency as can be made.

## FEED EFFICIENCY

pounds of feed required to produce one pound of product

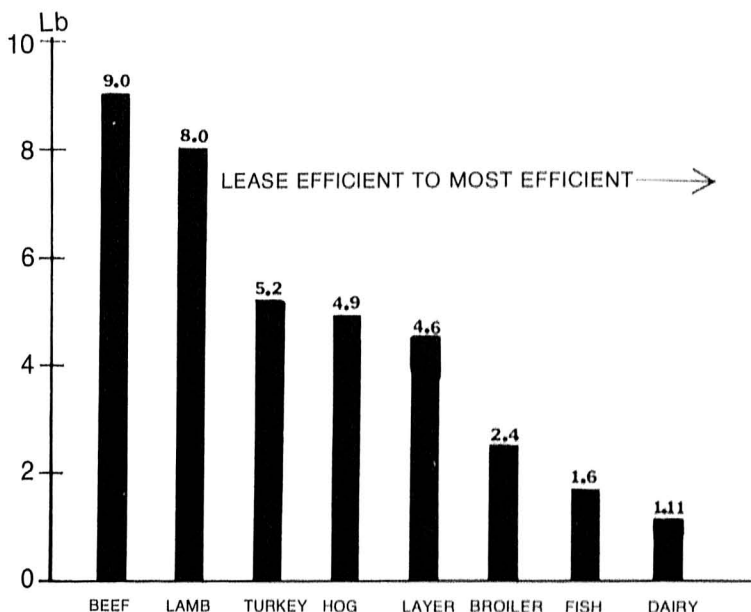


Fig. 6. Pounds of feed required to produce 1 lb of product. This shows that it takes 9 lb of feed to produce 1 lb of on-foot beef, whereas it takes only 1.11 lb of feed to produce 1 lb of milk. (Source: Table 1 of this chapter)

the needed animal proteins, and (3) to produce the needed manure for fertilizing the fields and fueling their homes. Thus, practicality dictates that a hungry world should consider the following facts in favor of sharing grain with animals, then consuming the animal products:

1. *Animals provide needed power.* A century ago, muscles provided 94% of the world's energy needs; coal, oil, and waterpower provided the other 6%. Today, the situation is reversed in the developed nations. They now obtain 94% of their energy needs from coal, oil, natural gas, and waterpower, and only 6% from the muscle power of men and animals. However, in the developing nations, cattle, water buffalo, and horses still provide much of the agricultural power. In this capacity, they contribute to man's food supply from plant sources. Such draft animals are a part of the agricultural scene of Asia, Africa, the Near East, Latin America, and parts of Europe; areas characterized by small farms (for example, India's farms average only 6.4 acres), low incomes, abundance of manpower, and lack of capital. But animals have certain advantages. They can be fueled on roughages to produce power, a most important consideration in time of energy shortage; and both cattle and water buffalo are "triple threat animals"—they're used for work, milk, and meat. Also, when it comes to tilling wet, muddy rice paddies, water buffalo are without a peer; and, under adverse conditions, they will outproduce cattle in power, milk yield, and butterfat.

## ENERGY (CALORIE) EFFICIENCY CONVERSION

kilocalories of feed required to produce one kilocalorie of product

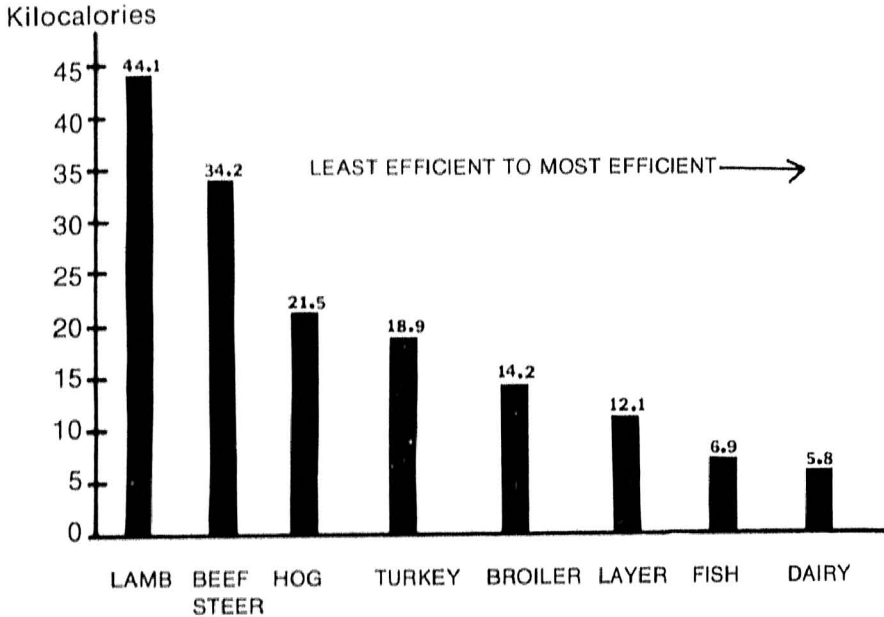


Fig. 7. Kilocalories in feed required to produce 1 kcal of product. This shows that it takes 44.1 kcal in feed to produce 1 kcal in lamb, whereas only 5.8 kcal in feed will produce 1 kcal in milk. (Source: Table 1 of this chapter)

Although the general trend in the world is toward more and more mechanization, animals will continue to provide most of the agricultural power for the small farm food crop agriculture in many of the developing countries.

2. *Animals provide needed nutrients.* Man cannot live by bread alone. The validity of this statement is generally recognized. Experiments and experiences give abundant evidence that animal products are far more than "empty" calories; they also provide all the essential amino acids (including lysine and methionine in which vegetable sources are deficient), minerals, and vitamins, along with digestibility and palatability. This is important, for how we live and how long we live are determined in large part by our diet.

It is estimated that the average American gets the percentages of his food nutrients shown in Table 2 from animal products. Foods of animal origin (meat, milk, and their various by-products) are especially important in the American diet; they provide 2/3 of the total protein, about 1/3 of the total energy, 4/5 of the calcium, 2/3 of the phosphorus, and significant amounts of the other minerals and vitamins needed in the human diet.

In addition to the nutrients listed in Table 2, meat, dairy products, and eggs are a rich source of vitamin B<sub>12</sub>, which does not occur in plant foods—only in animal sources and fermentation products. Also, it is

TAT  
**FEE TO FOOD EFFICIENCY RATING**  
**PROTEIN CONVERSION EFFICIENCY (Based on)**  
 in Feed Eaten by Various Kinds of  
 Protein Content of Res

Species	Unit of Production (on foot)	Feed Required to Produce One Production Unit				Dressing Yield		As % of Raw Product (carcass)
		Pounds	TDN <sup>1</sup>	DE <sup>2</sup>	Protein	Percent	Net Left	
Broiler	1 lb chicken	(lb) 2.4 <sup>7</sup>	(lb) 1.94 <sup>8</sup>	(kcal) 3,880	(lb) .21 <sup>8</sup>	% 72 <sup>13</sup>	(lb) .72	% 54 <sup>14</sup>
Dairy cow	1 lb milk	1.11 <sup>7</sup>	.9 <sup>8</sup>	1,800	.1 <sup>8</sup>	100	1.0	100
Turkey	1 lb turkey	5.2 <sup>7</sup>	4.21 <sup>8</sup>	8,420	0.46 <sup>8</sup>	79.7 <sup>13</sup>	.797	57 <sup>16</sup>
Layer	1 lb eggs (8 eggs)	4.6 <sup>7</sup>	3.73 <sup>8</sup>	7,460	.41 <sup>8</sup>	100	1.0	100 <sup>12</sup>
Fish	1 lb fish	1.6 <sup>9</sup>	.98	1,960	.57	65 <sup>10</sup>	.65	57 <sup>11</sup>
Hog (birth to 200 lb)	1 lb pork	4.9 <sup>18</sup>	3.67	7,340	.69	70 <sup>16</sup>	.70	44 <sup>17</sup>
Beef steer (yearling finishing period in feedlot)	1 lb beef	9.0 <sup>18</sup>	5.85	11,700	.90	58 <sup>16</sup>	.58	49 <sup>17</sup>
Rabbit	1 lb fryer	3.0 <sup>19</sup>	2.20	4,400	.48	55 <sup>19</sup>	.55	79 <sup>18</sup>
Lamb (finishing period in feedlot)	1 lb lamb	8.0 <sup>18</sup>	4.96	9,920	.86	47 <sup>16</sup>	.47	40 <sup>17</sup>

<sup>1</sup>TDN pounds computed by multiplying pounds feed (column to left) times percent TDN in normal rations. Normal ration percent TDN taken from M. E. Ensminger's books and rations, except for following: dairy cow, layer, broiler, and turkey from *Agricultural Statistics 1974*, p. 358, Table 518. Fish based on averages recommended by Michigan and Minnesota Stations and U.S. Fish and Wildlife.

<sup>2</sup>Digestible Energy (DE) in this column given in kcal, which is 1 Calorie (written with a capital C), or 1,000 calories (written with a small c). Kilocalories computed from TDN values in column to immediate left as follows: 1 lb TDN = 2,000 kcal.

<sup>3</sup>From *Lessons on Meat*, National Live Stock and Meat Board, 1965.

<sup>4</sup>Feed efficiency as used herein is based on pounds of feed required to produce 1 lb of product. Given in both percent and ratio.

<sup>5</sup>Kilocalories in ready-to-eat food = kilocalories in feed consumed, converted to percentage. Loss = kcal in feed + kcal in product.

<sup>6</sup>Protein in ready-to-eat food = protein in feed consumed, converted to percentage. Loss = pounds protein in feed + pounds protein in product.

<sup>7</sup>*Agricultural Statistics 1974*, p. 358, Table 518. Pounds feed per unit of production is expressed in equivalent feeding value of corn.

<sup>8</sup>Since pounds feed (column No. 2) per unit of production (column No. 1) is expressed in equivalent feeding value of corn, the values for corn were used in arriving at these computations. No. 2 corn values are TDN, 81% protein, 8.9%. Hence, for the dairy cow 81% x 1.11 = 0.9 lb TDN; and 8.9% x 1.11 = 0.1 lb protein.

<sup>9</sup>Data from report by Dr. Phillip J. Schaible, Michigan State University, *Feedstuffs*, April 15, 1967.

LE 1  
 BY SPECIES OF ANIMALS, RANKED BY  
 on Energy as TDN or DE and Crude Protein  
 Animals Converted into Calories and  
 dy-to-Eat Human Food)

Species	Ready-to-Eat, Yield of Edible Product (meat and fish deboned and after cooking)			Feed Efficiency <sup>4</sup>		Efficiency Rating			
	Amount from One Unit of Production	Calorie <sup>3</sup>	Protein <sup>3</sup>	(lb feed to pro- duce one lb product)		Calorie Efficiency <sup>5</sup>		Protein Efficiency <sup>6</sup>	
				%	(ratio)	%	(ratio)	%	(ratio)
	(lb)	(kcal)	(lb)	%	(ratio)	%	(ratio)	%	(ratio)
	.39	274	.11	41.7	2.4:1.0	7.1	14.2:1	52.4	1.9:1
	1.0	309	.037	.9	1.11:1.0	17.2	5.8:1	37.0	2.7:1
	.45	446	.146	19.2	5.2:1.0	5.3	18.9:1	31.7	3.2:1
	1.0 <sup>12</sup>	616	.106	21.8	4.6:1.0	8.3	12.1:1	25.9	3.9:1
	.37	285	.093	62.5	1.6:1.0	14.5	6.9:1	16.3	6.1:1
	.31	341	.088	20.4	4.9:1.0	4.6	21.5:1	12.7	7.8:1
	.28	342	.085	11.1	9.0:1.0	2.9	34.2:1	9.4	10.6:1
	.43	301	.08	35.7	2.8:1.0	6.8	14.6:1	6.7	6.0:1
	.19	226	.052	12.5	8.0:1.0	2.3	44.1:1	6.0	16.5:1

<sup>10</sup>*Industrial Fishery Technology*, ed. by Maurice E. Stansby, Reinhold Pub. Corp., 1963, Ch. 26, Table 26-1.

<sup>11</sup>*Ibid.* Reports that, "Dressed fish averages about 73% flesh, 21% bone, and 6% skin." In limited experiments conducted by A. Ensminger, it was found that there was a 22% cooking loss on filet of sole. Hence, these values—73% flesh from dressed fish, plus 22% cooking losses—give 57% yield of edible fish after cooking, as a percent of the raw, dressed product.

<sup>12</sup>Calories and protein computed basis per egg; hence, the values herein are 100% and 1.0 lb, respectively.

<sup>13</sup>*Marketing Poultry Products*, 5th Ed., by E. W. Benjamin et al., John Wiley & Sons, 1960, p. 147.

<sup>14</sup>*Factors Affecting Poultry Meat Yields*, University of Minnesota Sta. Bull. 476, 1964, p. 29, Table 11 (fricassee).

<sup>15</sup>*Ibid.* Page 28, Table 10.

<sup>16</sup>Ensminger, M.E., *The Stockman's Handbook*, 4th Ed., Sec. XII.

<sup>17</sup>Allowance made for both cutting and cooking losses following dressing. Thus, values are on a cooked, ready-to-eat basis of lean and marbled meat, exclusive of bone, gristle, and fat. Values provided by National Livestock and Meat Board (personal communication of June 5, 1967, from Dr. Wm. C. Sherman, Director, Nutrition Research, to the author), and based on data from *The Nutritive Value of Cooked Meat*, by Ruth M. Leverton and George V. Odell, Misc. Pub. MP-49, Appendix C, March 1958).

<sup>18</sup>Estimates by the authors.

<sup>19</sup>Based on information in *Commercial Rabbit Raising*, Ag. Hdbk. No. 309, USDA, 1966, and *A Handbook on Rabbit Raising*, by H. M. Butterfield, Washington State College Ext. Bull. No. 411, 1950.

## PROTEIN EFFICIENCY CONVERSION

pounds of feed protein required to produce  
one pound of product protein

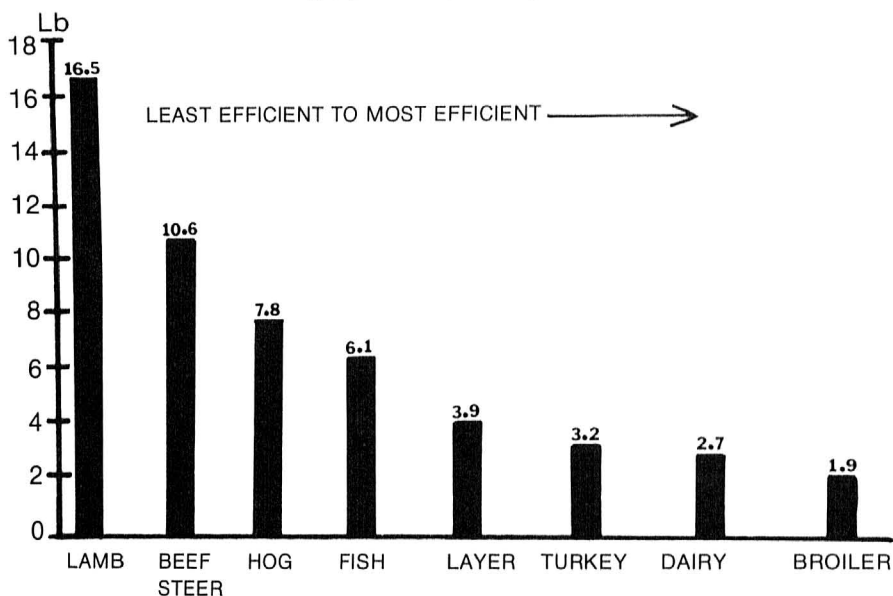


Fig. 8. Pounds of feed protein required to produce 1.0 lb of product protein. This shows that it takes 16.5 lb of feed protein to produce 1.0 lb of lamb protein, whereas only 1.9 lb of feed protein will produce 1.0 lb of broiler protein. (Source: Table 1. See column headed "Protein Efficiency.")



Fig. 9. Oxen pulling a stick (one-handed) plow. Draft animals are a part of the agricultural scene in most of the developing countries of the world. (By Burton Holmes, from Ewing Galloway)

noteworthy that the availability of iron in beef is twice as high as in plants.

About 2/3 of the world's protein supply is provided from plant sources, 1/3 from animal sources. Since the Food and Agriculture Organization of the United Nations reports that the world's diet needs animal protein in amounts equivalent to 1/3 of the total protein requirements, there should be ample animal protein, *provided* it were equally distributed. But it isn't. The people in the developed countries have 5 times as much high-quality animal protein per person as the people living in the developing countries. The gap between total protein (animal and vegetable combined) is not as wide (96.4 g vs 57.4 g per person per day in the developed and developing countries, respectively).

TABLE 2  
FOOD NUTRIENTS: PERCENTAGE OF TOTAL CONTRIBUTED  
BY LIVESTOCK AND POULTRY PRODUCTS<sup>1</sup>

	Food Energy	Protein	Fat	Carbohydrates	Calcium	Phosphorus	Iron	Vitamin A Value	Thiamin	Riboflavin	Niacin
	(%)										
Meat, fish, & poultry	19.9	41.2	34.2	0.1	3.5	25.9	29.3	22.2	27.7	24.2	45.7
Eggs	2.0	5.3	3.0	0.1	2.3	5.5	5.4	6.1	2.3	5.2	0.1
Dairy products, excluding butter	11.6	23.1	12.9	6.9	76.5	37.0	2.4	13.2	9.5	41.7	1.6
TOTAL	33.5	69.6	50.1	7.1	82.3	68.4	37.1	41.5	39.5	71.1	47.4

<sup>1</sup>*Agricultural Statistics 1974*, USDA, p. 560, Table 774.

The most important role of animal protein is to correct the amino acid deficiencies of the cereal proteins, which supply about two-thirds of the total protein intake, and which are notably deficient in the amino acid, lysine. The latter deficiency can also be filled by soybean meal, fish, protein concentrates and isolates, synthetic lysine, or high-lysine corn. But such products neither have the natural balance in amino acids nor the appetite appeal of animal protein.

As soon as people get enough calories—as they achieve higher incomes, as they approach affluency—they start turning away from a starch-oriented diet to one based on animal protein. This has happened in the United States, Canada, New Zealand, Sweden, and Japan. The affluent do not necessarily eat more animal protein products for nutritional reasons. Rather, they consume more meat, milk, eggs, and fish because they like them—because they derive a rich enjoyment and satisfaction therefrom, and because of the prestige that accrues from advancing from a cereal diet to an animal product diet.

3. *Much of the world's land is not cultivated.* More land throughout the world can, and will be, brought under cultivation and used for crop production. But, like the western range of the United States, vast acreages throughout the world—including arid and semiarid grazing

## U.S. FOOD NUTRIENTS FROM ANIMAL PRODUCTS

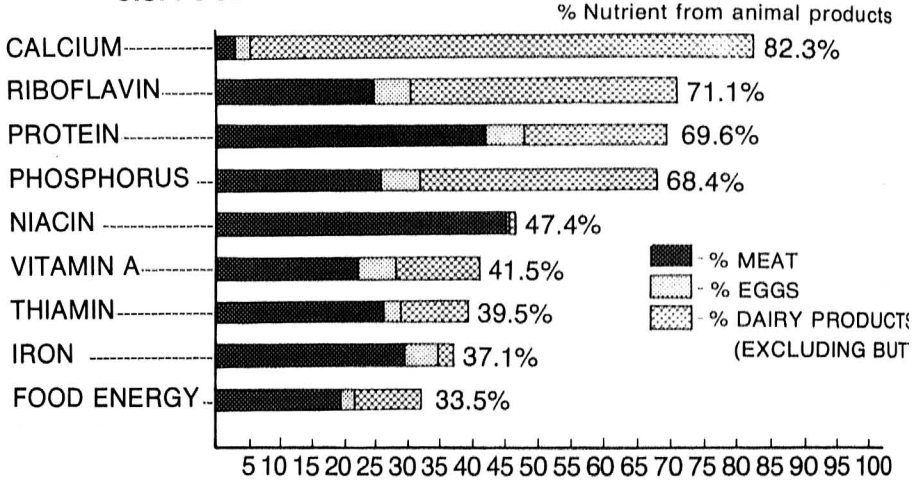


Fig. 10. Percentage of food nutrients contributed by animal products of the total nutrient supply in the U.S.



Fig. 11. A woman milking a water buffalo in India. Because of the large proportion of vegetarians in India (35 to 40%), milk is by far the nation's most important animal protein food. More than 50% of the milk produced in India is buffalo milk. In comparison with cow's milk, buffalo milk is higher in fat content (7.5% vs 4%) and sells at a higher price. (Courtesy, FAO, Rome, Italy)



lands; and brush, forest, cutover, and swamplands—are unsuited to the production of bread grains or any other type of farming; their highest and best use is, and will remain, for grazing and forest.



*Fig. 12. Vast areas throughout the world, such as this rough terrain, are not suited to cultivation. Hence, their only use is for grazing or forest.*

In the United States, only 21% of the land area of the 50 states is cultivated; 900 million acres, or 46.8%, of the land area, exclusive of Alaska and Hawaii, is pasture and grazing land. The enormous productivity of this vast area becomes apparent from the following figures: Every 22 lb of usable forage (grass, shrubs, and other plants) eaten by a ewe-lamb combination will produce about 1 lb of lamb; every 26 lb of usable forage eaten by a cow-calf combination will yield about 1 lb of calf; and every 10 lb of forage eaten by a calf will produce about 1 lb of calf.

In China, only 11.25% of the land is cultivated; yet this 7% of the world's cultivated land sustains a fourth of the world's population. North of China's Great Wall, life centers on pastoral areas; large flocks and herds of cattle, sheep, and horses roam these vast grasslands.

4. *Forages provide most of the feed for livestock.* Pastures and other roughages—feeds not suitable for human consumption—provide most of the feed for livestock, especially for ruminants (four-stomached animals such as cattle, sheep, goats, buffalo, and certain wild species including deer, antelope, and elk), throughout the world. Fortunately, the uniqueness of the ruminant's stomach permits it to consume forages, and, through bacterial synthesis, to convert such inedible (to humans) roughages into high-quality proteins—meat and milk. Hence, cattle and sheep manufacture human food from nonedible forage crops. Additionally, they serve as the primary means of storing (on the hoof, without refrigeration) such forage from one season to the next.

Despite grains being relatively plentiful in the United States, forages provide the bulk of animal feeds; pastures and other roughages account for 74% of the total feed of sheep, 77% of the feed of beef cattle, 80% of the feed of dairy cattle, and 63% of the feed of all livestock.<sup>4</sup>

TOTAL FEED CONSUMPTION BY ALL BEEF CATTLE, 1965-76\*

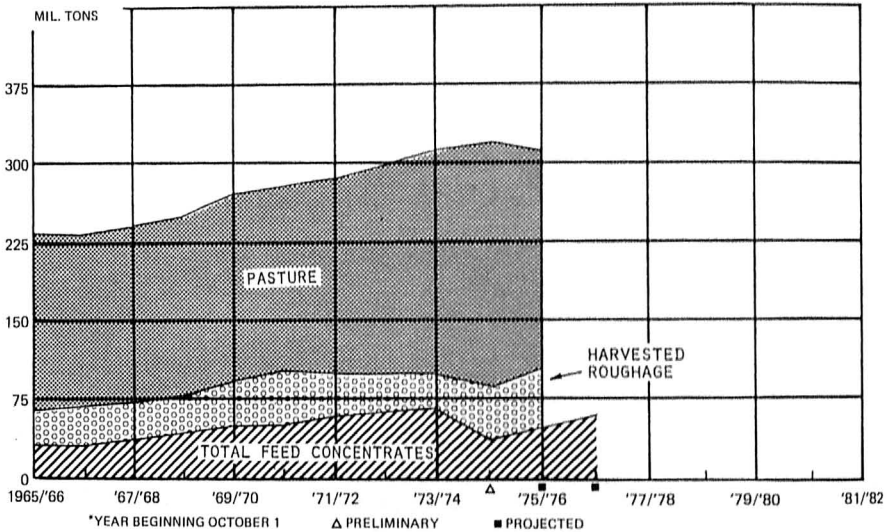


Fig. 13. Forages provide most of the feed of beef cattle. (Feed Situation, Sept. 1976, Economic Research Service, USDA, p. 16)

Even feedlot cattle consume relatively little grain in total. Generally speaking, feeder cattle, raised on milk and grass and that are to be grain fed, are put into the feedlot at weights of around 600 to 700 lb, to be fed to weights of about 1,050 lb. This means that they attain 60 to 65% of their weight gain before entering the feedlot. In the feedlot, it takes 9 lb of feed to make 1 lb of gain, with 6 lb of this consisting of grains and by-product feeds and 3 lb of roughage. Assuming a feeding period of 140 days and a gain of 450 lb in the lot, the total market weight (1,050 lb) would represent 2.57 lb of feed grain expended for each pound of gain ( $450 \times 6 = 2,700$ ; then,  $2,700 \div 1,050 = 2.57$ ). So, on a birth-to-market basis, it takes only 2 to 3 lb of grain per pound of weight gained. Less grain is consumed during those times when grains are scarce and high in price, at which times cattle are grazed longer and kept in the feedlot a shorter time. For example, had the steer in the above example been kept on pasture longer, had he been short fed for 90 to 100 days (instead of 140 days), and had he been fed to the same weight, but marketed at Good grade instead of Choice, each pound of on-foot weight would have required only about 1.8 lb of grain, which is comparable to the feed efficiency of broilers.

A Choice steer weighing 1,050 lb on foot will produce 454 lb of salable beef (processed, cut, and trimmed). As noted above, this steer can be finished on 2,700 lb of grain. This means that it requires slightly less than

<sup>4</sup>Feed Situation, May 1976, Economic Research Service, USDA, p. 38.

6 lb of grain to produce a pound of beef for the retail meat counter ( $2,700 \div 454 = 5.95$ ).

Of course, not all beef is grain fed; in 1975, about 40% of it was strictly grass fed. Besides, when grain is scarce and high in price, feeder steers are generally carried on grass to heavier weights (maybe 800 lb, instead of 650 lb) before being put in the feedlot, following which they are fed for only 100 days (short fed), rather than 140 days. This lessens the grain consumed per pound of salable beef.

5. *Food and feed grains are not synonymous.* Animals do not compete to any appreciable extent with the hungry people of the world for food grains, such as rice or wheat. Instead, they eat feed grains and by-product feeds—like field corn, grain sorghum, barley, oats, milling by-products, distillery wastes, and fruit and vegetable wastes—for which there is little or no demand for human use in most countries, plus forages and grasses—fibrous stuff that man can't eat. For example, in the United States only 3% of the corn—the major animal feed grain—is used for human food. Also, it is noteworthy that the feed grains which the United States ships overseas are used almost entirely for livestock and poultry production abroad.

6. *Ruminants utilize low-quality roughages.* Cattle, sheep, and goats efficiently utilize large quantities of coarse, high-cellulose roughages, including crop residues, straw, and coarse low-grade hays. Such products are indigestible by humans, but from 30 to 80% of the cellulose material is digested by ruminants.



*Fig. 14. Cattle can utilize efficiently large quantities of coarse, humanly inedible roughages, like cornstalks. This shows cows feeding on corn residue which had been harvested by mechanical means. (Courtesy, Iowa State University)*

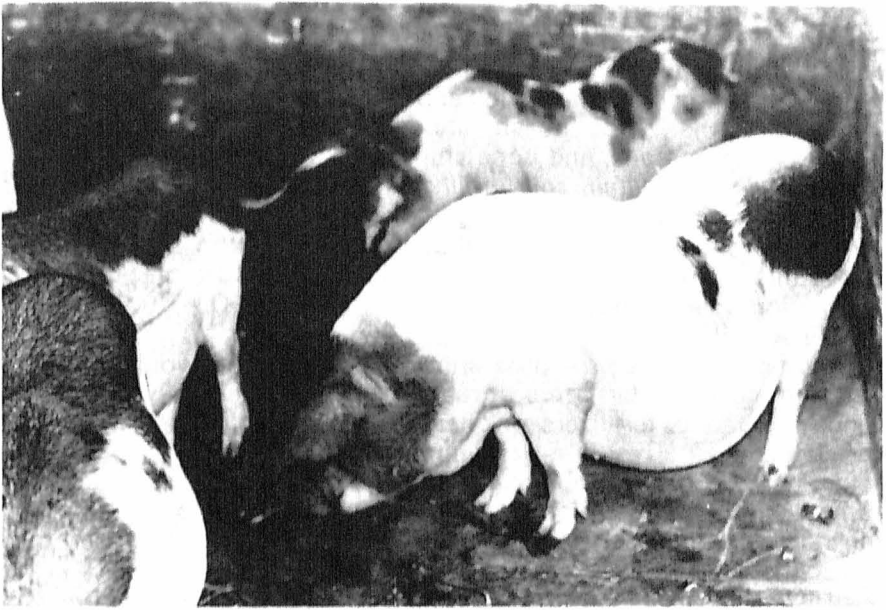
Of all U.S. crop residues, the residue of corn (cornstalks and husklage) is produced in greatest abundance and offers the greatest potential for expansion in cow numbers. In 1975, 66,905,000 acres of corn, yielding 86.2 bushels per acre, were harvested in this country. For the most part, over and above the grain, approximately 2 3/4 tons of dry matter produced per acre (40 to 50% of the energy value of the total corn plant) were left to rot in the field. That was 184 million tons of potential cow feed wasted, enough to winter 139 million dry pregnant cows consuming an average of 22 lb of corn refuse per head per day during a 4-month period. Mature cows are physiologically well adapted to utilizing such roughage. Moreover, when corn residue is used to the maximum as cow feed, acreage which would otherwise be used to pasture the herd is liberated to produce more corn and other crops. Also, there are many other crop residues which, if properly utilized, could increase the 139 million head figure given above.

7. *Animals utilize by-products.* Animals provide a practical outlet for a host of by-product feeds derived from plants and animals, which are not suited for human consumption. Some of these residues (or wastes) have been used for animal feeds for so long, and so extensively, that they are commonly classed as feed ingredients, along with such things as the cereal grains, without reference to their by-product origin. Most of these processing residues have little or no value as a source of nutrients for human consumption. Among such by-products are corncobs, cottonseed hulls, gin trash, oilseed meals, beet pulp, citrus pulp, molasses (cane, beet, citrus, and wood), wood by-products, rice bran and hulls, wheat milling by-products, and fruit, nut, and vegetable refuse. It is estimated that each year ruminants convert more than 9 million tons of by-products into human food.

8. *Animals provide elasticity and stability to grain production.* Live-stock feeding provides a large and flexible outlet for the year-to-year changes in grain supplies. When there is a large production of grain, more can be fed to livestock, with the animals carried to heavier weights and higher finish. On the other hand, when grain supplies are low, herds and flocks can be maintained by reducing the grain that is fed and by increasing the grasses and roughages in the ration. Thus, when grains are in short supply, fewer slaughter cattle are grain fed—more are grass finished. In the years ahead, depending on future grain supplies and prices, it is predicted that fewer than two-thirds of the U.S. domestic beef supply will come from feedlot cattle, in comparison with the 77% of U.S. slaughter cattle that were grain fed in 1973. Also, during periods of high-priced grains, heavier feeder cattle will go into feedlots, and they will be fed for a shorter period on less grain and more roughage than when grains are more abundant and cheaper.

In the future, animals will increasingly be "roughage burners," with the proportion of grain to roughage determined by grain supplies and prices.

Beef cattlemen, dairymen, and sheepmen will more and more rely upon the ability of the ruminant to convert coarse forage, grass, and by-product feeds, along with a minimum of grain, into palatable and nutritious food for human consumption, thereby competing less for



*Fig. 15. Chinese hogs on Ping Chou People's Commune, Kwang Tung Province, in China. Their ration consisted of two by-products—rice millfeed and bagasse (the pith of sugarcane), along with water hyacinth—all of which the pigs ate with relish. In China, swine utilize millions of tons of otherwise wasted crop residues and by-products. (Photo by A. H. Ensminger)*

humanly edible grains. The longtime trend in animal feeding will be back to roughages; increasingly, flesh will be grass.

9. *Animals step up the protein content and quality of foods.* Grains, such as corn, are much lower in protein content in cereal form than after conversion into meat, milk, or eggs. On a dry basis, the protein contents of selected products are corn, 10.45%; beef (Choice grade, total edible, trimmed to retail level, raw), 30.7%; milk, 26.4%; and eggs, 47.0%.<sup>5</sup> Also, animals increase the quality (e.g. biological value) of the protein.

10. *Ruminants convert nonprotein nitrogen to protein.* Ruminant animals (cattle, sheep, and goats) can use nonprotein nitrogen, like urea, to produce protein for humans in the form of meat and milk.

11. *Animals provide medicinal and other products.* Animals are not processed for meat alone. They are the source of hundreds of important by-products, including some 100 medicines such as insulin, adrenalin, and heparin, without which the life-style and health of many people would be altered.<sup>6</sup>

<sup>5</sup>*Composition of Foods*, Ag. Hdbk. No. 8, Agricultural Research Service, USDA.

<sup>6</sup>The count on the number of medicines derived from animals varies, perhaps due to (a) whether or not certain derivatives are counted, and (b) whether or not experimental products, as well as commercial, are included. Swift and Company lists 90 such products, the American Meat Institute states that over 100 different pharmaceuticals come from cattle alone, while the National Live Stock and Meat Board pegs the number of different medicines coming from animals at 134.

It takes the pancreas of 26 steers to provide enough insulin to keep one diabetic alive for 1 year; and there are about 5 million diagnosed diabetics in this country, of which one-fourth require regular insulin.

Besides medicines, many familiar products are derived from animals, including leather, shoe polish, photographic film, soap, lubricants, candles, glue, buttons, and bone china, to name a few.

12. *Animals maintain soil fertility.* Animals provide manure for the fields, a fact which was often forgotten during the era when chemical fertilizers were relatively abundant and cheap. One ton of average manure contains 18 lb of nitrogen (N), 9 lb of  $P_2O_5$ , and 13 lb of  $K_2O$ . At 1977 retail prices (per pound: N = 25¢,  $P_2O_5$  = 20¢, and  $K_2O$  = 10¢, it's worth \$7.58 per ton.

The energy crisis prompted concern that farmers would not have sufficient chemical fertilizers at reasonable prices in the years ahead. Since nitrogenous fertilizers are oil- and petroleum-based, there is cause for concern. As a result, a growing number of American farmers are returning to organic farming; they are using more manure—the unwanted barnyard centerpiece of the past 30 years, and they are discovering that they are just as good reapers of the land and far better stewards of the soil.

It is noteworthy that China has kept its soils productive for thousands of years, primarily through the use of night soil (human waste) and every other kind of manure, applied to the land in primitive, but effective, fashion. Every Chinese peasant recites the following teaching of Chairman Mao Tse-tung: "The more pigs, the more manure; and the more manure, the more grain." Indeed, animal manure is very precious in China; it is carefully conserved and added to the land. Manure is used as a way in which to increase yields of farmland already under cultivation.

## ONE TON OF AVERAGE MANURE

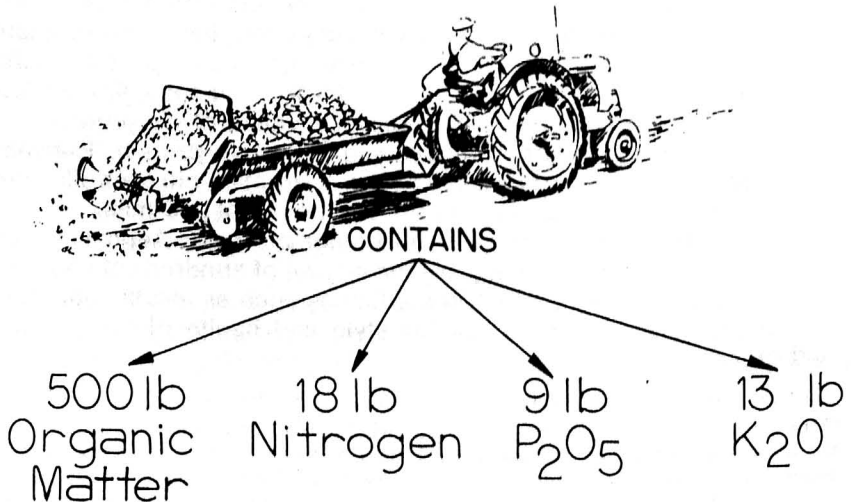


Fig. 16. The contents of 1 ton of average manure.

## Meeting the Feeds vs Foods Dilemma

Practicality dictates that a hungry world should, and will, proceed in about the following order in meeting the feeds vs foods dilemma:

1. Consume a higher proportion of humanly edible grains and seeds, and their by-products, directly—without putting them through animals, simply because approximately five times more people can be fed by doing it this way.

2. Utilize a higher proportion of roughages to concentrates in animal rations as increasing quantities of cereal grains are needed for human consumption.

3. Give priority to those species that can utilize a maximum of humanly inedible feeds and a minimum of products suitable for human consumption. This would favor beef cattle, dairy cattle, and sheep, provided they are fed a maximum of pasture and other roughages. Both poultry and swine may compete with man for grains. Nevertheless, it is expected that further increases in poultry will come, primarily because of their efficiency as converters of protein from feed to food; and it is expected that there will be further increases in swine, especially in China, where pigs are scavengers and manure producers par excellence.

4. Propagate, to the extent of available feed resources, the most efficient feed to food species converters (see Table 1). This means dairy cows, fish, and poultry. Because beef cattle and sheep are at the bottom of the totem pole when it comes to feed efficiency, the pressure will be to eliminate them, except as roughage consumers.

5. Increase the within-species efficiency of all animals and eliminate the inefficient ones. This calls for more careful selection and more rigid culling than ever before.

6. Improve pastures and ranges. Good pasture will produce 200 to 400 pounds of beef or lamb per acre annually (in weight of young weaned, or in added weight of older animals); superior pastures will do much better.

7. Utilize manure as a resource—for fertilizer, feed, and energy.

The search goes on! Scientists throughout the world will speed the process—they will go on researching, discovering, creating, and advancing. Then by sharing and applying their know-how, each of us and the whole world will have a brighter tomorrow. Our dreams will come true—faster and more abundantly, with more food and animals in our future.

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