Animal Agriculture and Human Nutrition

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Explosive increases in world population and mounting food deficits have created an urgent demand for more food. In fact, there appears to be need for a new source of food that can be brought into large scale production quickly enough to forestall the approaching famine and to buy time for medical and social scientists to bring the population under control. It is in this light that animal agriculture must be evaluated now and in the future. In this connection several points are pertinent as follows:

1. Animal protein is an excellent food and a generous supply improves human diets.
2. Much of the world is poorly supplied with animal products.
3. Animal protein will have to compete with other protein foods in the human diet.
4. Can animal agriculture survive?

1. Animal protein is an excellent food and a generous supply improves human diets.

Meat, milk, fish, eggs and game are liked by all people and these foods are of excellent quality. Per capita consumption of meat, eggs and dairy products in the United States are shown in Table 1. Not covered in this chart are the 4.5 kg. of fish and 1.1 kg. of game eaten by our people.

As protein is one of the most important nutrients supplied by animal products, it should be considered in more detail. When fish and game

Table 1. Per Capita Nutrient Consumption and Amounts Supplied by Meat, Eggs and Dairy Products in The United States (Byerly, 1966)

Nutrient	Consumed	Amount Supplied by Animal Products	Percent of Total
Energy, Kcal.	3150	1118	35.5
Protein, gm.	95	61.8	65.0
Fat, gm.	145	82.5	56.9
Carbohydrate, gm.	372	28.7	7.7
Calcium, gm.	0.96	0.74	81.9
Phosphorus, gm.	1.50	0.99	66.0
Iron, mg.	16.50	5.49	36.0
Vitamin A, I.U.	7800	3393	43.5
Thiamine, mg.	1.83	0.76	41.1
Riboflavin, mg.	2.26	1.63	72.3
Niacin, mg.	21.2	8.99	42.4

protein are added, present figures indicate that about 65 of the 95 gm. of protein consumed per day by Americans come from animal sources.

Byerly (1) has calculated the protein consumption by Americans from 1909 to 1963 and found that total consumption of protein has been relatively constant through the years, but that the consumption of animal protein has increased each year. It is of great interest to note that total protein intake has remained constant, even though the National Research Council (2) has shown that our total intake of protein can be reduced as the percentage of animal protein in the diet increases; animal proteins provide a better balance of amino acids than do the protein supplied by cereals.

"The FAO Committee (3) on protein requirements has estimated the minimal daily need for adults to be between 0.3 to 0.35 gm./kg. when the diet contains protein of maximal nutritive value." Proteins of animal origin are of maximal nutritive value and there is no doubt that high levels of animal protein in human diets are desirable.

2. Much of the world is poorly supplied with animal products.

Anderson (4) has published figures shown in Table 2, which indicate that not all of the world's people enjoy the level of animal protein in their diets as do those of us in the United States. He also projected these figures to 1970, in which he showed that population will increase from 3 billion to 3,613,000,000. Using a reference standard a per capita intake of 60 gm. protein intake per day, of which 10 gm. would come from animal protein, it appears that there was a deficiency of 8.7 million metric tons of non-fat dry milk, or its protein equivalent of other animal food products, in 1960 and that this will grow to 6.5 billion tons in 1970.

It appears that we were able to feed 3 billion people in 1960, although not very well for a large part of the world. Koonz (5) estimates that 500 million people are now underfed and that one-half of the world's

Table 2. Population and Animal Protein Consumption in 1960 (Anderson, 1964)

Area	People		Anmial Protein
	Millions	% of Total	Per capita per day, gm.
U.S.A.	180	6.0	64.0
Canada	18	0.6	64.0
Europe	425	14.2	40.0
U.S.S.R.	214	7.1	30.0
Latin America	209	7.0	23.0
Communist Asia	713	23.8	3.2
Other Asia	976	32.5	11.0
Africa	259	8.6	12.0
Oceania	13	0.4	69.0
Total	3,007		

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population or more suffer from varying degrees of malnutrition. It now appears that within the next 3 to 4 decades that we will have to provide food for an additional 3 billion people. In other words the world's population is now expanding at about 65 million per year (6).

To illustrate the point another way (6), if we were to assume that the per capita needs of protein is 23.7 kg., then we would have required 71.2 billion kg. of protein to feed 3 billion people. If population grows at 1.8% an additional 1.36 billion tons are required each year. After 10 years (7), 91 billion tons would be required and after 40 years, 142 billion kg. would be required annually (Table 3). A doubling of the present protein supply would not solve the problem since it is estimated that 62% of the world's population is underfed in protein. Also Horan (8) estimates that 50% or more of population of countries with average national diets are deficient in animal protein. The problem is probably more serious in affluent societies when nutrition habits of teenagers are considered.

It has been suggested by many workers that there is a direct correlation between the consumption of animal protein and per capita income. Income is only one factor affecting the consumption of animal protein. It requires land resources to produce animal protein and the United States has ample land resources for the production of animal proteins for the present and next generation. Most of the world is not so fortunate as citizens of the United States as is shown by the data of Table 4, which shows total land area, estimated area of arable land and of pasture, hectares of agricultural land per person and per animal unit in several geographical areas of the world (9). Animal units are arbitrarily assigned as follows: each cow, horse, camel, buffalo, mule, and ass has a value of one animal unit; each pig, sheep, or goat has value of 0.2 unit; and for each head of poultry, 0.02 unit. These figures, at best, are averages and there is doubt regarding the estimation of grazzing land available. For example, several authorities in the United States believe that the United States has more land which could be used for grazing purposes.

The world had one person for each 1.3 hectares and one animal unit for each 2.5 hectares in 1960. Communist Asia, China, has only 0.4 hectare per person but has an animal unit per 1.9 hectares. Even though population pressure has made these people utilize many plant products as human food rather than to feed these to animals, China

Table 3. Future Protein Needs (Gray, 1964)

Population	Protein needs[1] billion (kg)
Three billion	71.20
Increase 1.8% per year	1.36
After 10 years	91.00
After 40 years	142.00

[1] Annual per capita need, 23.7 kg.

Table 4. Total and Agricultural Land in The Various Areas of The World, and Agricultural Land Per Person and Per Animal Unit in These Areas (FAO, 9)

Area	Land				Agricultural land (1960)	
	Total	Arable	Grazing	Total agri-cultural	Per person	Per animal unit
	----	Millions of hectares[1]		----	Hectares	Hectares
U.S.A.	936	185	257	442	2.4	3.4
Canada	998	42	21	63	3.5	3.9
Europe	493	153	90	243	0.6	1.2
USSR	2240	230	370	600	2.8	4.4
Latin Am.	2272	102	386	488	2.3	1.7
China	976	109	178	287	0.4	1.9
Other Asia	1740	341	246	587	0.6	1.4
Africa	3020	253	591	844	3.3	4.4
Oceania	854	34	458	492	37.8	7.0

[1] One hectare is equal to 2.47 acres.

still has more animal units than the United States (147 vs. 128 million units). Thus Byerly emphasized"—population pressure is not likely to eliminate livestock as producers of animal food. Their scavenger role is an important one."

3. Animals will have to compete with other protein foods in the human diet.

Animal protein will have to compete with other sources of food protein. Also it is known that some livestock compete with man for food. For example, swine and poultry consume feed grains which humans can consume directly. It is generally known that humans obtain more edible protein per unit of crop when the plant food is consumed directly rather than when the crop is fed to livestock, which are later eaten.

Table 5 shows the amount of edible protein, which it is estimated could be supplied from good land when the products are fed to beef cattle, dairy cattle, or when planted to soybean or alfalfa, with the protein contained therein being processed for human consumption.

Byerly (1) has put the figures in a more realistic form. His figures indicate that milk cows, as presently managed in the United States, convert feed protein with an efficiency of about 30 percent; laying flocks being 20 percent; and broilers being 25 percent. It is estimated that the cattle industry, in general, provides food protein with an efficiency of about 10 units of feed protein for 1 unit of food protein. Swine appear to be somewhere between beef cattle and laying hens. These figures make it obvious that animal products cannot compete with those of plant origin or, perhaps, synthetics if efficiency is the sole criteria.

Agricultural Economists and others have compiled figures which indicate that during the last 25 years we have made tremendous improvement in feed efficiencies in poultry but that such improvements in

Table 5. Estimated Edible Protein Production Per Hectare of Good Land

Commodity	Per Year (kg)
Beef	50
Milk	86
Soybean	504
Alfalfa	675

other animals have not been so dramatic. The major improvements in dairy, and beef, production have come about because of decreased mortality and increased grain feeding. Many people ask how long can we afford the extensive grain feeding now used in both industries. It is true, however, that grain feeding has allowed extensive use of urea as a protein substitute. For example, it is estimated that we will be utilizing 200,000 tons of feed-grade urea by 1970 in feeding our beef and dairy cattle, sheep, and goats. This will represent the replacement of 667,000 tons of soybean or cottonseed meal.

Most world authorities agree that we cannot expand animal production at a rate to provide all peop:e with an adequate diet. For this reason much atention is being given to developing other protein sources without necessarily de-emphasizing animal production. A partial list of non-animal protein sources follows:

Algae. The common algae which grows on farm ponds has simple nutrient requirements and can convert non-protein nitrogen to protein at a fast rate. The quality of the protein appears to be good and easily produced.

Microorganisms. The culture of microorganisms, which have high protein content, appears to have been initiated by Champagnat *et al.* (11) in 1963. This report stimulated many major oil companies to initiate feasibility studies on fermentation processes based upon crude petroleum products. It appears possible to treat 500 tons of gas oil per day in a continuous fermentation unit and recover 50 tons of dried microorganism and 450 tons of improved oil; the oil being improved because the microorganisms used the waxes as an energy source. Their only other dietary needs are sources of simple nitrogenous compounds and minerals. Tables 6 and 7 show the composition of the protein-vitamin concentrate.

Champagnat *et al.* (1963) compared the rate of production of protein using microorganisms with that in a bovine: "One 500 kg. cow suitably fed by grazing synthesized 0.5 kg. protein per 24 hours. Five hundred kg. of living microorganisms in a continuous fermentation unit, suitably fed with petroleum hydrocarbons, nitrogen, minerals, and air should produce, according to our experience, 2500 kg. microorganisms in 24 hours in which there are 1250 kg. of protein, thus industrial production may be 2500 times as fast as the natural method." Research on petro-protein production appears to be under the sponsorship of several major oil companies and techniques remain as secrets of these companies.

Table 6. Composition of Protein-Vitamin Concentrate Produced From Microorganism Fed Petroleum Waxes (11)

Ingredient	%
Dry matter	93.00
Total Nitrogen	6.90
Protein	43.60
Fat	18.50
Carbohydrate	21.90
Minerals	4.40
Calcium	0.21
Pho·phorus	1.25
Potassium	0.50
Sodium	0.06

Table 7. Percentage Amino Acid Composition of Microorganism Protein Obtained From Microorganism Grown On Petroleum Waxes (11)

Amino acid	Wheat Flour	Beef	Milk	Petroleum Produced Protein
Leucine	7.0	8.0	11.0	7.0
Isoleucine	4.2	6.0	7.8	3.1
Valine	4.1	5.5	3.1	8.4
Threonine	2.7	5.0	4.7	9.1
Methionine	1.5	3.2	3.2	1.2
Cystine	1.9	1.2	1.0	0.1
Lysine	1.9	10.0	8.7	11.6
Arginine	4.2	7.7	4.2	8.0
Histidine	2.2	3.3	2.6	8.1
Phenylalanine	5.5	5.0	5.5	7.9
Tryptophan	0.8	1.4	1.5	1.2
Percent Protein	13.2	59.4	33.1	43.6

The production of protein from petroleum waxes outlook is thought to be bright by many authorities. There appears to be an unlimited supply of crude petroleum waxes, which is the energy source and the process could be of mutual benefit to the petroleum industry. Using the figures, which are available, it would appear that one ton of microorganism protein could be produced for each 50 tons of crude petroleum processed. If this were extended, it would appear that only 150 million tons of petroleum would have to be processed to produce enough protein to meet the need of the world's population of human beings. As this would represent less than one-sixth of the 1500 million tons of paraffinic petroleum refined last year, it does appear possible to produce 10 times as much protein as we need in human nutrition. There remain many production problems before this can be applied.

Strong efforts are being made to include soybean, cottonseed, peanuts and sesame meal in the diets of people in protein-deficient areas. Likewise, there is much effort devoted toward the use of soybean protein in our own affluent society. Food processors have used for many years soy flour as a binder and extender in meat loaf, sausage, and bakery products. Edible grade soy protein is a more recent manufacturing venture. The products are prepared from high quality, dehulled soybean from which the oil and soluble constituents are extracted leaving a product containing 70 percent protein. Further extraction produces an isolated soy protein, which contains 90 percent protein. Both products are widely used in cereal products, bread, meat products, baby food and candies. Spun soybean fibers are now being used as meat in hot dogs, beef, chicken, turkey, and other meat dishes.

There is much effort now being placed upon the utilization of cottonseed protein by the human population of Latin America. Altschul (12) reported that over 5 million tons of this product were used for this purpose in 1965. Research on this product is quite active, especially since cottonseed meal contains a toxic product, gossypol. Amino acid supplementation of diets containing the oil meals plus the cereals made the combination equal in quality to milk or meat protein (13); the amino acids were methionine, lysine and threonine. All of these amino acids can be made synthetically. In fact, lysine, methionine and methionine hydroxyanalogue are manufactured commercially.

The most limiting amino acid of wheat is lysine. Many people have proposed that the bakeries in the United States enrich the bread from wheat with lysine, but our authorities doubt this necessity because of our consumption of milk and meat products, which contain high levels of lysine. Perhaps consideration should be given to the enrichment of the wheat now sent to India. For example, if to the 15 million tons of wheat sent to India in 1964 we had added 0.26 percent lysine it would have made it a better source of protein. Such supplementation would have required 38,300 metric tons of lysine, more than the world supply. The price of lysine is $8.60 per kg.; however, if the demand were increased to 30 to 50,000 tons per year, the price would drop to $2.00 per kg. (10).

Some authorities believe the ultimate in protein nutrition will have been reached when we can synthesize all of the amino acids in amounts and at a price, which would allow us to feed our entire population from this source.

England is supporting research designed to extract protein from green plants. Pirie (14) recently reviewed their progress and I quote from his review,"—machinery was perfected for the processing of fresh leaves, both at the 1-ton-per-hour rate and in 100- to 200 kilogram batches, and extracting one-half to three-fourths of the protein. The protein is better nutritionally than most seed protein and can be presented on the table in palatable forms. Leaf protein is probably one of the foodstuffs that will be used, especially in the wet tropics, in ameliorating the protein shortage that now exists."

Corn. Currently there is much interest in the mutant strain of corn developed by the Purdue workers. Rats fed Opaque 2 corn gained three times as fast as those fed the best Indiana hybrids (15). Preliminary tests with chicks, swine and humans indicate that the product is superior when fed to these species. Because this drastic change in nutritional value is the result of a single mutant gene, work is underway with the objective of uncovering such mutants in milo, wheat, rice, barley and other grains. If the other cereals can also be improved by the introduction of a single mutant gene, we should make further progress toward meeting the protein needs of our expanding population.

4. Can animal agriculture survive?

Historically livestock have been scavengers from man's food supply. Ducks, chickens, geese and pigs have been used in much of the western world. Goats have had the same function in much of the Middle East. We must turn our attention to finding better ways of using these animals for this purpose. New Jersey workers have recently re-evaluated the use of garbage in swine feeding (16). Several research stations have reported that chicken litter can serve as a protein source for fattening cattle.

There are 500 million tons (fresh weight) of manure produced by livestock in this country alone. Are we in America making efficient use of this product? The answer is, of course, no. In fact, manure disposal appears to be a major problem of the present cattle feedlots. It is interesting to contrast this with Wetsern Europe, where animal manure is a valuable commodity.

More coarse roughage such as straw, corn cobs etc. can be used as feeds for our cattle and sheep fed maintenance rations. Animals can be used to utilize offal found in any quantity anywhere. For example, there is much blackstrap or cane molasses available in quantity in many parts of the world at an economical price. In some countries it is used to spread on dirt roads to keep down dust. This product is a valuable livestock feed. In a recent experiment, the author fed growing sheep a ration composed of one lb. of cottonseed hulls and allowed the sheep free access to a liquid mixture composed, in percent, of: cane molasses, 94.0; urea, 4.0; minerals, 2.0; and vitamins A and D. These animals gained 0.11 lb. per day and produced excellent carcasses. Such gains are poor by production standards in the United States but are remarkable when it is considered that 90 percent of the protein was supplied by urea and that only synthetic or waste products were fed.

Wood manufacturers have found that the processing of wood to make pressboard and other pressed wood products require much steam pressure and high temperature. In such treatment, about 10 percent of the hemicellulose is extracted. Feeding results with cattle and sheep indicate that this product is a good source of carbohydrate. What about a diet composed of wood molasses, urea and low quality roughage for ruminants? Experimentation in such areas must be increased for there are literally millions of tons of wood fibers burned yearly because of disposal problems. Such practices increase air pollution problems in America.

The world has millions of hectares of land, which will produce nothing but forage. This forage must be used for the production of animal products for human consumption. This involves public lands in the United States and elsewhere. Such land must be fertilized, grazed properly, and properly supplemented with all elements needed for optimum animal growth.

Man must obtain better utilization of the forages available now. Figure 1 (Lewis, 17) shows how one could increase protein production by grain supplementation when the nitrogen level of forage is too high. Farmers, by adding grain in the proper amount and proper time to cattle or sheep grazing forages having excess protein, could possibly produce more human food in milk or flesh than could be obtained if the grain were eaten directly.

Mineral imbalances are important factors when the stress of high production is placed on livestock. Figure 2 shows some interrelationships of minerals. We much seek these out and correct the imbalances by feeding supplemental minerals or by making major changes in soil fertilizers.

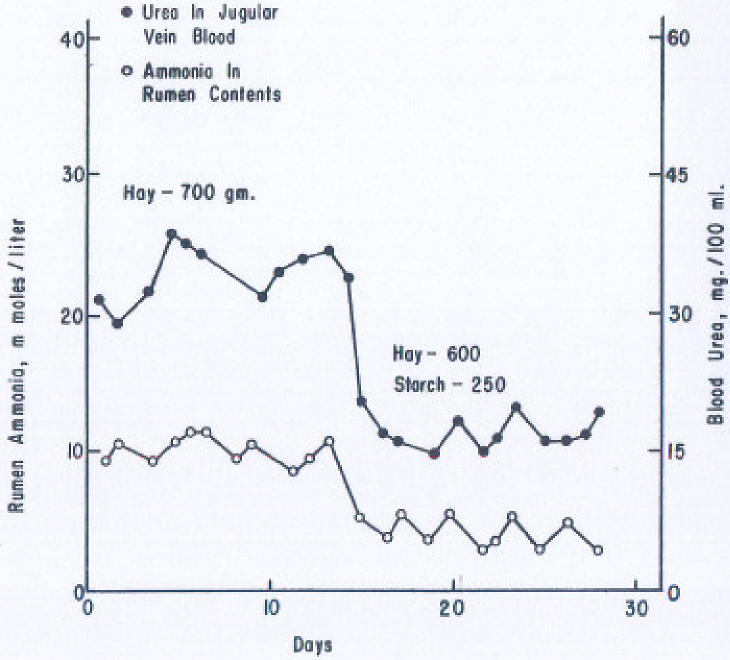

Figure 1. Blood urea and rumen ammonia concentration of changing the diet of sheep. (Lewis, 1957)

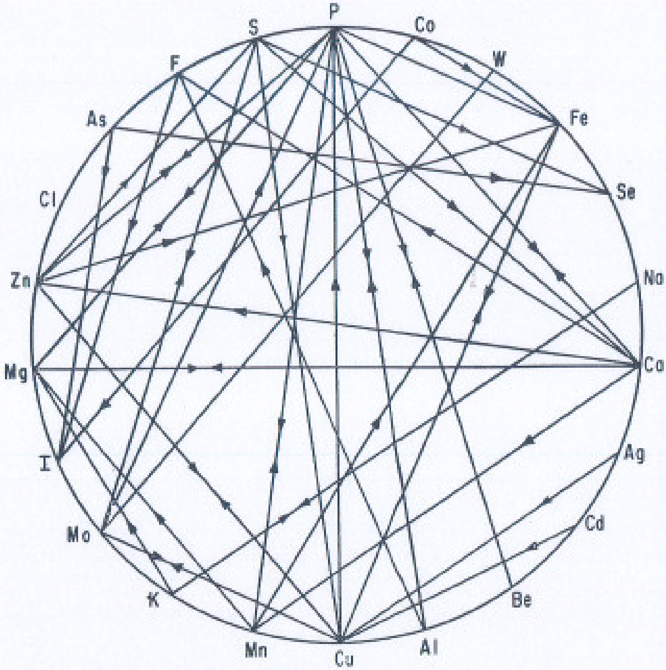

Figure 2. Mineral interrelationships in animals.

Animal products are nutritious and we like them in our diet. The production of these products is expensive in terms of conversion of feed protein to food protein; however, animals can be used as scavengers of human food supply. Man must investigate ways of utilizing our animals better for this purpose. Man must also obtain more animal products from the lands, which can not be used to grow crops other than forages. Proper supplementation of forages as regards minerals, protein and energy are prime considerations.

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The Cumulative Influence of Level of Wintering on the Lifetime Performance of Beef Females Through Seven Calf Crops

Craig Ludwig, S. A. Ewing, L. S. Pope and D. F. Stephens

The type of forage available to range beef cows during the winter months dictates in many cases that supplemental protein and often supplemental energy be provided to insure acceptable cow performance.

The amount of supplemental feed required is of economic importance in terms of feed cost as well as the ultimate influence on reproductive performance and milk production of the dam.

Several experiments have been conducted at this station which relate to this subject, and progress reports have been made periodically. This report summarizes performance of spring-calving cows wintered at different levels from weaning through seven calf crops.