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Potential for Energy Conservation in Feeding Livestock and Poultry in the United States

by

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ABSTRACT

This research report estimates the magnitude of the potential that exists to conserve fossil fuel energy in feeding livestock and poultry in six regions of the U.S. Comparing the quantity of energy contained in least cost feed rations with that embodied in energy minimizing rations, it was found that more than 37 trillion BTU could be conserved annually. This is the energy equivalent of nearly 298 million gallons of gasoline.

However, this energy savings would not be without a substantial cost to farmers and ultimately consumers. Farmers would have to pay about $13 more per ton of feed, or in the aggregate about $490 million in additional feed cost (in the six regions). The cost of the associated products would have to rise to meet this increased feed cost: milk by 3 to 25 cents per hundredweight, eggs by 2.5 to 7.5 cents per dozen, broilers by 1.3 to 2 cents per pound and turkeys by 3 to 4.5 cents per pound. Thus, while considerable energy savings are possible, the cost of such savings would appear to be prohibitive at the present time.

KEY WORDS: Energy Conservation, Energy Use, Feed Rations, Dairy, Beef, Layers, Broilers, Turkeys, Swine, Least Cost Rations, Least Energy Rations.

This report examines the extent to which least cost feed rations are not energy minimizing rations. It considers the magnitude of the energy savings that are possible in the short run (given current ingredient supply levels) if energy minimizing rations were fed. Further, the report analyzes the consequent economic implications of feeding these rations to livestock and poultry in six farm production regions of the U.S. The report examines the particular ingredient composition of least cost and least energy feed rations for dairy and beef cattle, swine, layers, broilers and turkeys for a specific point in time (February, 1976). Suggestions are also made as to the direction for future research.

Procedure

A linear programming model was developed that would allow the comparison of both least cost and least energy feed rations for six species of livestock and poultry. Particular feed rations were minimized with respect to cost and then with respect to energy (measured in terms of the BTU's required to produce, process and transport the feed ingredients[1]) per hundredweight of ration subject to constraints for crude protein, feed energy, fat, fiber and amino acids (for poultry). The analysis was simplified by excluding constraints for minerals and vitamins; the justification for such an approach lies in the availability of vitamin and mineral supplements that can be added to feed rations to meet specific needs. Tables 1 and 2 present the minimum and maximum constraints used in the linear programming model for the particular rations considered. Quantities of the individual ingredients in the various feed rations were further constrained by (1) the ability of the particular species to consume the ingredients and (2) the historic availability of the ingredients in the consumption regions considered. Corn grain and soybean oil meal were the only feed ingredients that were not constrained in the analysis. The consumption regions examined were the Northeast (encompassing New England, New York, New Jersey, Pennsylvania, Delaware and Maryland), the Lake States (Minnesota, Wisconsin and Michigan), the Corn Belt (Iowa, Missouri, Illinois, Indiana and Ohio), the Pacific States (Washington, Oregon and California), the Southern Plains (Texas and Oklahoma) and the Southeast (Alabama, Georgia, South Carolina and Florida).[2]

Commercial feed manufacturers in these six regions were contacted and asked to provide a list of feed ingredients that they used in formulating their rations. They also provided prices paid for these ingredients in February of 1976. These prices were used in developing the regional least cost feed rations. USDA

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[1]A British thermal unit (BTU) is the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit at, or near, its point of maximum density. The energy content of the various power sources is commonly measured in terms of BTU's. For example, one kwh of electricity is rated at 3,413 BTU; gasoline at 125,000 BTU per gallon; diesel fuel at 140,000 BTU per gallon; L.P. gas at 95,000 BTU per gallon; and natural gas at 100,000 BTU per therm.

[2]These regions correspond to the Farm Production Regions identified by the Economic Research Service.

Table 1. General Minimum and Maximum Constraints Specified for Poultry Ration

Type of Constraint	Broiler Starter Ration	Broiler Finisher Ration	Layer Ration	Turkey Starter Grower Ration	Turkey Grower Finisher Ration
Minimum:					
Metabolizable energy (mcal/cwt.)	145.00	145.00	130.00	125.00	135.00
Crude protein (%)	24.00	20.00	16.00	28.00	18.00
Arginine (%)	1.40	1.20	0.80	1.60	1.10
Lysine (%)	1.25	1.10	0.53	1.50	1.00
Methionine (%)	0.46	0.40	0.28	0.52	0.35
Methionine + Cystine (%)	0.86	0.75	0.53	0.87	0.58
Trypotophan (%)	0.23	0.20	0.11	0.26	0.17
Fat (%)	3.00	3.00	3.00	3.00	3.00
Maximum:					
Fiber (%)	4.00	4.00	5.00	10.00	10.00
Added Fat (%)	10.00	10.00	10.00	10.00	10.00

Table 2. General Minimum and Maximum Constraints Specified for Dairy, Beef and Swine Rations

Type of Constraint	Dairy Ration	Dairy Supplement Ration	Beef Supplement Ration	Swine Ration
Minimum:				
Energy (mcal/cwt.)	60.0[a/]	60.0[a/]	40.0[b/]	145.0[c/]
Crude protein (%)	16.0	32.0	40.0	16.0
Fat (%)	2.5	2.5	2.5	1.0
Maximum:				
Fiber (%)	10.0	10.0	10.0	5.0
Total Fat (%)	5.0	5.0	5.0	5.0

a/ Net energy for lactating cows.

b/ Net energy for gain.

c/ Metabolizable energy for swine.

estimates were used for the amount of fossil fuel energy utilized in the production and processing of these feed ingredients and additional estimates were made of the energy required in transporting the ingredients (see Appendix Tables 1 and 2). Throughout, no energy allocation was assigned for the manufacture of fixed inputs such as tractors, trucks and processing equipment. At the farm level, the production estimates reflect only the operational or variable farm inputs such as gasoline, the energy utilized in irrigation, and the BTU's required to produce and apply fertilizer. Where processing was considered, only the energy required to perform a certain task (e.g., dehydration) was counted. The estimates cited in Appendix Tables 1 and 2 should be construed as preliminary, first estimates that require refinement in future analysis.

Appendix Table 14. Least Energy 16% Layer Rations for Specified Consumption Regions, 1976

Feed Ingredients	Northeast	Lake States	Corn Belt	Pacific	Southern Plains	Southeast
	Consumption Region					
	pounds					
Feed grains						
Corn	42.6	51.3	42.0		56.9	51.0
Sorghum				12.4		
Barley	5.0			15.0		
Oats	7.5	7.5	7.5			2.5
Wheat			5.0	5.0	2.5	
Oilseed Meals						
Soybean Oil Meal (49%)	15.7	20.1	19.6	21.2	14.5	18.9
Cottonseed Oil Meal (41%)			2.5	5.0	5.0	2.5
Animal protein ingredients						
Meat and Bone Meal				5.0		
Poultry Byproduct Meal	2.5				1.0	
Grain byproducts						
Hominy Feed	5.0		1.0	2.5		1.0
Wheat Middlings	10.0	10.0	10.0	10.0	10.0	10.0
Wheat Bran	10.0	10.0	10.0	9.9	7.6	10.0
Rice Bran				2.5	2.5	2.5
Other ingredients						
Molasses				3.0		
Animal Fat	1.7	1.1	2.4	8.5		1.6
	100.0	100.0	100.0	100.0	100.0	100.0
BTU per hundredweight	207,000	189,000	186,000	258,000	195,000	200,000
Relative energy (186,000 = 100)	111	102	100	139	105	108
Cost analysis						
Cost per hundredweight	$5.97	$5.55	$5.34	$7.13	$6.16	$5.81
Relative cost ($4.83 = 100)	124	115	111	148	128	120

and 14,000 BTU per hundredweight. In general, the inclusion of these other energy consuming activities would not change the results of the analysis.

The Northeast. Farmers in the Northeast will feed approximately seven million tons of commercially mixed dairy, layer and broiler feed in 1976 (Table 3). The amount of fossil fuel energy required to produce, process and transport

Table 3. Regional Summary of Least Cost and Least Energy Rations, Northeast, 1976

Feed Rations	Least Cost Ration		Least Energy Ration		Percent Diff. in $/cwt	Percent Diff. in BTU/cwt.
	$/cwt.	BTU/cwt.	$/cwt.	BTU/cwt.		
16% Dairy Ration	$5.14	240,000	$5.62	198,000	+9.3%	-17.5%
32% Dairy Supplement	$6.06	277,000	$6.74	214,000	+11.2%	-22.7%
20% Broiler Ration	$6.43	289,000	$7.50	258,000	+16.6%	-10.7%
24% Broiler Ration	$6.99	300,000	$7.81	276,000	+11.7%	-8.0%
16% Layer Ration	$5.50	290,000	$5.97	207,000	+8.5%	-28.6%

these seven million tons exceeds 38 trillion BTU. However, if energy minimizing rations were fed instead of those that minimize cost, an energy savings on the order of seven trillion BTU (nearly 19 percent) could be realized; this is equivalent to somewhat more than 57 million gallons of gasoline annually.

Nearly 40 percent of the volume of feed consumed in the Northeast is dairy ration. On average, the least cost dairy rations that would be fed (on the basis of February 1976 prices) would contain about 244,000 BTU per hundredweight. If energy minimizing rations were substituted, the BTU content would fall to about 200,000 (an energy savings of 18 percent). In the aggregate nearly 2.4 trillion BTU could be saved by feeding least energy rations; this is equivalent to about 19 million gallons of gasoline. However, the energy savings would not be without a consequent economic cost to dairymen and ultimately consumers. On average, dairymen would have to pay nearly $10.00 more per ton of mixed feed. This increased feed cost would mean that dairy farmers would have to receive an additional $0.12 per hundredweight of milk just to break even. While the latter figure may appear to be small, it should be realized that the dairymen's feed bill would increase by nearly $27 million and that this increased cost would be reflected as either a higher price in the supermarket or a decrease in farm income. (For purposes of analysis, it is assumed that the price of farm products reflects the increased feed cost.)

In feeding layers and broilers in the Northeast, it is estimated that approximately 3.7 and 1.1 trillion BTU respectively could be saved annually if energy minimizing rations were fed. Together this is roughly equivalent to 38 million gallons of gasoline. To accomplish this energy savings the cost of the associated products would have to rise. The price of eggs would need to increase by 2.6 cents per dozen and the cost of broilers by two cents per pound. In the aggregate, poultry farmers in the Northeast would have to pay about $59 million more for their feed.

Thus, in the Northeast, considerable energy savings could be achieved. However, the cost of substituting least energy rations for least cost rations would be great — on the order of $85 million, or $1.19 per 100,000 BTU saved.

The Lake States. While the Lake States are an important region in terms of their production of livestock and poultry products, a smaller proportion of the feed volume fed is purchased as a commercially mixed feed (Table 4). Farmers, especially dairymen and swine producers, are more likely to feed their own

Table 4. Regional Summary of Least Cost and Least Energy Rations, Lake States, 1976

Feed Rations	Least Cost Ration		Least Energy Ration		Percent Diff. in	Percent Diff. in
	$/cwt.	BTU/cwt.	$/cwt.	BTU/cwt.	$/cwt.	BTU/cwt.
16 % Dairy Ration	$4.57	244,000	$5.24	185,000	+14.7%	-24.2%
32% Dairy Supplement	$5.64	265,000	$6.58	196,000	+16.7%	-26.0%
40% Beef Supplement	$6.69	249,000	$7.29	205,000	+9.0%	-17.7%
16% Layer Ration	$5.06	226,000	$5.55	189,000	+9.7%	-16.4%
18% Turkey Ration	$5.39	264,000	$6.77	211,000	+25.6%	-20.1
28% Turkey Ration	$6.52	274,000	$7.95	229,000	+21.9%	-16.4%
16% Swine Ration	$5.05	203,000	$5.24	185,000	+3.8%	-8.9%

grains and purchase a protein supplement or an occasional feed ingredient than they are to buy a commercially mixed feed ration. For example, dairymen will feed their milk cows more than six million tons of grain and other concentrates in 1976; however, only about ten percent of this volume will be purchased in the form of a commercially mixed feed ration.

It is estimated that Lake State farmers will feed their livestock and poultry about three million tons of commercially mixed feed this year. If energy minimizing rations were substituted for least cost rations, roughly 2.5 trillion BTU could be saved; this is comparable to about 20 million gallons of gasoline. In the aggregate, farmers would have to pay about $42 million more for their feed, or $1.70 per 100,000 BTU saved.

As a consequence of the increased feed cost, farmers would have to receive a higher price for their product. For example, dairymen would need a milk price about three cents per hundredweight higher; egg producers would have to receive almost three cents more per dozen eggs; turkey producers would need an additional four cents per pound of bird marketed.

The Corn Belt. Of the six regions considered, the Corn Belt was found to be both the least cost and least energy region. It is estimated that Corn Belt farmers will feed more than seven million tons of commercially mixed feed in 1976 (Table 5). If least energy rations were fed, an energy savings of more than five

Table 5. Regional Summary of Least Cost and Least Energy Rations, Corn Belt, 1976

Feed Rations	Least Cost Ration		Least Energy Ration		Percent Diff. in	Percent Diff. in
	$/cwt.	BTU/cwt.	$/cwt.	BTU/cwt.	$/cwt.	BTU/cwt.
16% Dairy Ration	$4.51	235,000	$4.96	178,000	+10.0%	-24.3%
32% Dairy Supplement	$5.25	243,000	$5.58	188,000	+6.3%	-22.6%
40% Beef Supplement	$5.95	235,000	$6.17	199,000	+3.7%	-15.3%
16% Layer Ration	$4.83	224,000	$5.34	186,000	+10.6%	-17.0%
18% Turkey Ration	$5.10	250,000	$6.25	207,000	+22.5%	-17.2%
28% Turkey Ration	$5.87	252,000	$6.71	224,000	+14.3%	-11.1%
16% Swine Ration	$4.77	205,000	$4.99	179,000	+ 4.6%	-12.7%

trillion BTU could be realized; this is the energy equivalent of about 42 million gallons of gasoline.

However, the energy savings would increase the farmer's feed bill by more than $61 million, or $1.16 per 100,000 BTU saved. Again, the cost of the associated products would have to rise: milk by about five cents per hundredweight; eggs by nearly three cents per dozen; turkey by three cents per pound.

The Pacific States. In contrast to the Corn Belt, the amount of fossil fuel energy embodied in Pacific feed rations is greater than in any other region considered. This is primarily a reflection of the fact that the Pacific States are net importers of feed ingredients from distant suppliers (Table 6). However, the

Table 6. Regional Summary of Least Cost and Least Energy Rations, Pacific, 1976

Feed Rations	Least Cost Ration		Least Energy Ration		Percent Diff. in $/cwt.	Percent Diff. in BTU/cwt.
	$/cwt.	BTU/cwt.	$/cwt.	BTU/cwt.		
16% Dairy Ration	$5.26	314,000	$5.80	229,000	+10.3%	-27.0%
32% Dairy Supplement	$5.92	364,000	$7.08	263,000	+19.6%	-27.7%
40% Beef Supplement	$6.62	393,000	$7.68	309,000	+16.0%	-21.4%
20% Broiler Ration	$6.90	403,000	$7.82	332,000	+13.3%	-17.6%
24% Broiler Ration	$7.47	412,000	$8.07	361,000	+8.0%	-12.4%
16% Layer Ration	$5.78	358,000	$7.13	258,000	+23.4%	-27.9%
18% Turkey Ration	$6.08	369,000	$7.61	277,000	+25.2%	-24.9%
28% Turkey Ration	$6.85	411,000	$8.30	323,000	+21.2%	-21.4%

energy involved in transport is not well reflected in the price of ingredients. Thus, substantial energy savings could be achieved by substituting low energy ingredients for those with a high BTU content.

For example, Pacific dairymen will feed their cows about 2,250,000 tons of commercially mixed feed this year. If the least energy dairy rations were fed, nearly 3.9 trillion BTU could be saved over least cost feeding. This is comparable to about 31 million gallons of gasoline. However, the cost of milk would have to increase by more than 19 cents per hundredweight for farmers to break even, or cover their increased feed cost.

By feeding least energy beef rations, 2.2 trillion BTU could be saved. Likewise, in feeding layers, broilers and turkeys energy savings on the magnitude of 6.1 trillion BTU could be realized. To achieve these savings, the price of eggs would have to increase by 7.5 cents per dozen, broilers by 1.6 cents per pound and turkeys by 4.5 cents per pound.

In the aggregate, Pacific farmers would see their feed cost increase by more than $139 million (more than $20 per ton), or $1.14 per 100,000 BTU saved. The total energy savings would be equivalent to the energy content of nearly 98 million gallons of gasoline.

The Southern Plains. It is estimated that about five and one-half million tons of commercially mixed feed will be consumed in the Southern Plains in 1976 (Table 7). If farmers in the region fed least energy rations rather than least cost rations, nearly 4.4 trillion BTU could be conserved annually. This would represent a regional savings of more than 15 percent and would be comparable

Table 7. Regional Summary of Least Cost and Least Energy Rations, Southern Plains, 1976

Feed Rations	Least Cost Ration		Least Energy Ration		Percent Diff. in $/cwt.	Percent Diff. in BTU/cwt.
	$/cwt.	BTU/cwt.	$/cwt.	BTU/cwt.		
16% Dairy Ration	$5.03	252,000	$5.95	171,000	+18.3%	-32.1%
32% Dairy Supplement	$5.90	259,000	$6.90	199,000	+16.9%	-23.2%
40% Beef Supplement	$6.88	248,000	$7.45	220,000	+8.3%	-11.3%
20% Broiler Ration	$7.05	304,000	$7.80	252,000	+10.6%	-17.1%
24% Broiler Ration	$7.66	321,000	$8.14	273,000	+6.3%	-15.0%
16% Layer Ration	$5.57	248,000	$6.16	195,000	+10.6%	-21.4%
16% Swine Ration	$5.49	223,000	$6.03	183,000	+9.8%	-17.9%

to about 35 million gallons of gasoline. To achieve this savings, farmers would have to pay about $12 more per ton of feed; in the aggregate, this would amount to an increased feed cost of about $66 million, or $1.52 per 100,000 BTU saved.

Again, the cost of the various products would need to increase if farmers were to break even. Milk would have to increase by nearly 25 cents per hundredweight, eggs by 3.3 cents per dozen and broilers by 1.3 cents per pound.

The Southeast. In the Southeast it is estimated that about 45 million gallons of gasoline equivalent could be saved annually if energy minimizing rations were fed. The greatest share of the potential savings would be in feeding layers and broilers (Table 8).

Table 8. Regional Summary of Least Cost and Least Energy Rations, Southeast, 1976

Feed Rations	Least Cost Ration		Least Energy Ration		Percent Diff. in $/cwt.	Percent Diff. in BTU/cwt.
	$/cwt.	BTU/cwt.	$/cwt.	BTU/cwt.		
16% Dairy Ration	$5.00	237,000	$5.48	196,000	+9.6%	-17.3%
32% Dairy Supplement	$5.61	240,000	$6.52	199,000	+16.2%	-17.1%
40% Beef Supplement	$6.32	260,000	$7.06	202,000	+11.7%	-22.3%
20% Broiler Ration	$6.33	284,000	$7.23	245,000	+14.2%	-13.7%
24% Broiler Ration	$6.85	298,000	$7.53	261,000	+9.9%	-12.4%
16% Layer Ration	$5.35	226,000	$5.81	200,000	+8.6%	-11.5%
16% Swine Ration	$5.32	222,000	$5.48	196,000	+3.0%	-11.7%

Currently Southeastern farmers feed about six and one-half million tons of layer and broiler ration. The feeding of least energy rations could reduce the embodied energy in these feeds by about 13 percent. In total about 4.3 trillion BTU could be saved (roughly equivalent to 35 million gallons of gasoline). To achieve this savings the price of eggs would need to increase by about 2.5 cents per dozen and broilers would have to go up by 1.7 cents per pound to cover the increased feed cost associated with the energy minimizing rations.

Similarly about six million gallons of gasoline equivalent could be conserved in feeding dairy cows (at a cost of 13 cents per hundredweight of milk) and about 4.7 million gallons in feeding beef cattle and swine. In the aggregate for the region, nearly 5.7 trillion BTU could be saved at a cost of $99 million, or $1.74 per 100,000 BTU saved.

Regional Energy Savings, Summary Comments. The analysis of feed rations fed to livestock and poultry in the six regions considered reveals that substantial energy savings could be achieved if energy minimizing rations were utilized. In total an estimated 37.2 trillion BTU could be conserved annually. This would represent an energy savings of about 18 percent and be comparable to saving nearly 298 million gallons of gasoline. (It could be noted that this quantity of gasoline is roughly the amount consumed by New Hampshire automobile drivers in a year.)

The greatest potential for energy conservation lies in the Pacific States where the fossil fuel energy embodied in feed rations could be reduced by 25 percent, and a total of nearly 98 million gallons of gasoline equivalent could be saved annually. Likewise, more than 57 million gallons of gasoline could be saved in the Northeast.

As to energy savings by species, for the regions considered, nearly 78 million gallons of gasoline could be saved in feeding least energy rations to dairy cattle, about 41 million in feeding beef cattle, 104 million in feeding layers, nearly 42 million in feeding broilers, 16 million in feeding turkeys and nearly 18 million in feeding energy minimizing rations to swine. However, the relative cost of achieving these savings varies from species to species. Whereas it would cost $0.93 per 100,000 BTU saved to utilize the least energy rations for dairy cattle, feeding the least energy rations to turkeys would cost $2.33 per 100,000 BTU saved. For the other species considered, the relative costs are $1.44 for beef cattle, $1.16 for layers, $2.10 for broilers and $0.93 for swine.

Considering all of the species and regions analyzed, the least cost feed ration has an energy content of 270,165 BTU per hundredweight and an associated cost of $5.73. The least energy ration, by comparison, has 221, 315 BTU and a cost of $6.38 per hundredweight. In other words, the least energy ration contains about 18 percent less embodied energy but costs 11 percent more than the weighted least cost feed ration. This energy savings could be achieved at a cost of $1.32 per 100,000 BTU saved.

It should again be mentioned that the energy savings cited above reflect only the current potential for conservation. The model employed is constrained by the historic availability of feed ingredients in the regions considered. If these historic constraints could be relaxed, if the supply of certain low energy ingredients could be expanded, greater energy savings could be realized. These adjustments would entail long run changes in crop production and marketing facilities associated with the production and manufacture of feed ingredients.

Implications of the Analysis

The analysis raises a number of significant policy issues in terms of the short run adjustments that could be made to conserve energy. Moreover, there is a need to further examine the implications of energy minimizing feed rations in terms of both the short run and long run adjustments in livestock feeding. Some of the implications of the study and possible directions for expanded research follow.

Feeds with High Energy Embodiments. It is necessary to fully examine the economic implications of no longer feeding certain feedstuffs which have a high energy content. For example, brewers and distillers dried grains presently account for about 1.5 percent of the feed ingredients used in formulating commercially mixed feed rations in the U.S. However, both of these byproduct feeds have a high energy component on the level of ten million BTU per ton of product. Good feed substitutes, for example, exist for these dried grains, and a substantial energy savings could be achieved by feeding these other ingredients. Yet, the implications of such substitutions must be considered.

For instance, what would be done with these byproduct feeds if they were not fed to livestock? What would be the economic and energy cost of alternative means of disposal? If they were to be disposed of by sanitary landfill, for example, one would have to consider the environmental impact of burying the byproducts in a wet form. On a more positive side, one should ask if there are alternative technologies available which could reduce the energy used in drying the wet grains. Further, to what extent could these byproducts be fed in a wet form to livestock?

There are other high energy feed ingredients in current use: corn gluten feed and meal, dried beet and citrus pulp, fish meal, dried whey, suncured and dehydrated alfalfa meal, and urea. Of these, alfalfa meal and urea are of particular interest. In 1976 it is likely that some 1.5 million tons of alfalfa meal and about one-half million tons of urea will be fed in the U.S. Yet, the energy embodied in these protein ingredients is substantial: about 16 million BTU per ton of dehydrated alfalfa meal, 10 million per ton of suncured alfalfa meal and 25 million per ton of urea. Protein substitutes which are lower in energy content are available; for example, soybean oil meal has an energy level of less than five million BTU per ton. However, the economic impact of no longer utilizing these protein ingredients could be severe. The impact of no longer feeding alfalfa meal, for instance, would manifest itself not only within the processing industry associated with alfalfa meal, but also would extend to the farm level and affect many local economies. Such ramifications demand attention before any conservation policy be considered which would either limit or eliminate the feeding of these (or other) ingredients.

Alternative Feed Ingredients. An obvious extension of the present research would be to expand its scope. New and unusual feed ingredients should be considered. At present a number of agricultural experiment stations are conducting research on the feeding of dried poultry litter and manure to livestock and poultry. However, while this may be an economic feed ingredient, it appears to have a high energy content (somewhat less than 12 million BTU per ton) due to the dehydration involved.

Further, this study has considered only the most commonly fed ingredients; many feedstuffs in short supply and limited use such as peanut hulls, flaxseed meal, cull peas and triticale have not been considered in the analysis. Equally important would be the consideration of food processing wastes that could be utilized as feed ingredients. This would entail, however, a technological assessment of the fossil fuel energy that might be required in utilizing the waste in feed rations; further, examination would have to be given to public health considerations and other possible legal constraints. It is possible that some of these neglected ingredients could have a good feeding value and yet a low energy component — and there may be room for expanding the supply of the ingredients given a competitive price.

Changes in Model Specification. The present analysis could be improved by a more complete specification of constraints with respect to the vitamin and mineral requirements of the species considered and the amino acid requirements of swine. This would bring the analysis more closely in line with conventional feed rations suggested by animal nutritionists. Further, it would provide a realistic base for discussion with and evaluation by nutritionists.

Extension of the Energy Analysis. While the study has considered the implications of feeding least cost and least energy rations, it has not explored the possibility of lesser energy savings. It would be worthwhile to examine the implications of, say, a five percent energy reduction on the cost of feed rations. Less than full energy savings would certainly reduce the cost impact on energy conservation and make the implementation of such practices easier. This area should be given further attention.

The present analysis is constrained by the historic availability of feed ingredients in the regions considered. An extended analysis would focus on the possible long run adjustments in feeding livestock and poultry and in crop production and land use. That is, it may be the case that from the perspective of energy conservation we, as a Nation, should be producing (and feeding) more barley and oats than we currently do while, on the other hand, producing (and feeding) less corn and sorghum. Also, an extended analysis should consider the production functions involved from the perspective of the amount of product produced per unit of time; perhaps, our milk and beef cattle should be pastured more than they presently are. The feasibility of such hypotheses should be considered from an economic standpoint.

In general, the aggregate long run supply and demand implications of energy minimizing rations should be examined in terms of the effect on U.S. cropping patterns, the impact of farm input costs and the associated product cost to consumers, farm income and the viability of commercial supply firms. Attention should also be given to possible shifts in regional supply sources that could reduce the amount of energy related to the transport of feed ingredients; likewise, possible shifts in transport mode should be considered as a way to reduce energy utilization.

The Total Balanced Ration. A logical extension of the analysis would analyze the entire animal food situation. Not all of the feed fed to livestock is a commercially mixed ration; a substantial portion of the diet, particularly for ruminants, comes from farm-raised crops and forage. It is necessary to consider the farmer's options as those of the feedmill have been considered here. One should consider the effect of minimizing energy usage on farm feeding programs, cropping plans, the size of livestock operation that a given amount of cropland could support (if it were planted to energy minimizing crops), forage feeding, and the subsequent impact on the net income of farmers and the cost of producing various livestock products.

Concluding Remarks

This report has attempted to estimate the magnitude of the potential that exists to conserve energy in feeding livestock and poultry in six regions of the U.S. Comparing energy embodied in least cost feed rations with the quantity contained in energy minimizing rations, it was found that more than 37 trillion BTU could be conserved annually. This is the energy equivalent of nearly 298 million gallons of gasoline. However, this energy savings would not be without a consequent cost. Farmers would have to pay about $13 more per ton of feed, or in the aggregate about $490 million in additional feed cost (for the six regions). Assuming that the increased feed cost was reflected in higher product prices, the milk price would have to rise by 3 to 25 cents per hundredweight, eggs by 2.5 to 7.5 cents per dozen, broilers by 1.3 to 2 cents per pound and turkeys by 3 to 4.5 cents per pound. Thus, while considerable energy savings are possible, the cost of such savings would appear to be prohibitive at the present time.

Appendix Table 1. Embodied Fossil Fuel Energy Input in Various Feed Ingredients, BTU per cwt. of Final Product, 1976

Feed Ingredients[a/]	Embodied Fossil Fuel Energy			
	Production[b/]	Transport[c/]	Processing	Total
	BTU per cwt. of final product			
Dehydrated Alfalfa Meal (20%)	268,500	11,300	521,350	801,150
Dehydrated Alfalfa Meal (17%)	268,500	11,300	521,350	801,150
Suncured Alfalfa Meal (15%)	258,900	10,900	240,000	509,800
Barley (12%)	161,000	3,000	---	164,000
Barley, West Coast (9%)	158,500	3,000	---	161,500
Brewers Dried Grains (26%)	---	---	500,000	500,000
Corn (9%)	181,800	3,600	35,300	220,700
Corn Gluten Feed (21%)	---	---	536,100	536,100
Corn Gluten Meal (42%)	---	---	536,100	536,100
Cottonseed Oil Meal (41%)	---	---	55,500	55,500
Distillers Dried Grains (28%)	---	---	500,000	500,000
Animal Fat	---	---	470,000[d/]	470,000
Fish Meal (Menhaden) (61%)	---	---	800,000	800,000
Fish Meal (Anchovy) (64%)	---	---	800,000	800,000
Hominy Feed (11%)	---	---	100,000	100,000
Meat and Bone Meal (50%)	---	---	370,000[d/]	370,000
Cane Molasses (3%)	---	---	250,000	250,000
Oats (12%)	113,000	5,300	---	118,300
Oats, West Coast (9%)	112,500	5,300	---	117,800
Poultry Byproduct Meal (65%)	---	---	417,300	417,300
Rice Bran (13%)	---	---	13,900	13,900
Sorghum (9%)	249,500	3,000	---	252,500
Soybean Oil Meal (44%)	189,900	3,900	47,600	241,400
Soybean Oil Meal (49%)	189,900	3,900	47,600	241,400
Hard Wheat (12%)	170,500	3,000	---	173,500
Wheat Bran (15%)	---	---	13,900	13,900
Wheat Middlings (16%)	---	---	13,900	13,900
Urea (281%)	---	---	1,248,500	1,248,500
Dried Beet Pulp (9%)	---	---	521,350	521,350
Dried Citrus Pulp (7%)	---	---	521,350	521,350
Dried Whey (12%)	---	---	2,290,000	2,290,000

a/ The approximate protein level of the various ingredients is listed after the ingredient.

b/ Based on 1974 crop production data.

c/ Allocation for only the first transport off-farm to the processing point.

d/ Includes an estimate for the assembly of the raw product.

Appendix Table 2. Embodied Fossil Fuel Energy Attributable to the Transport of Various Feed Ingredients, BTU's per cwt., 1976

Consumption Region	Feed Ingredients				
	Feed Grains	Oilseed Meals	Grain Byproducts	Animal Protein Ingredients	Other Ingredients
			BTU's per cwt.		
Northeast	27,500	46,900	44,900	13,100	20,700
Lake States	8,300	15,400	15,200	15,700	36,700
Corn Belt	8,700	11,300	18,900	17,000	42,200
Pacific	87,000	94,600	50,300	11,700	13,100
Southern Plains	31,700	40,800	35,100	18,400	30,300
Southeast	30,600	18,400	36,200	13,200	22,200

Based on the average distance of feed manufacturers from principal suppliers in 1969; see E.F. Hodges, G.C. Allen and G.A. Davis, The Formula Feed Industry, 1969: A Statistical Summary, Statistical Bulletin No. 485, Economic Research Service, U.S. Department of Agriculture, Washington, D.C., May 1972.

Appendix Table 3. Least Cost 16% Dairy Rations for Specified Consumption Regions, February 1976

Feed Ingredients	Consumption Region					
	Northeast	Lake States	Corn Belt	Pacific	Southern Plains	Southeast
	pounds					
Feed grains						
Corn	54.6	59.7	55.9	15.6	12.5	60.4
Sorghum			7.5	25.0	40.0	
Barley	5.0			15.0		
Oats					5.0	
Wheat				5.0	2.5	
Oilseed meals						
Soybean Oil Meal (44%)			0.1	1.9		1.6
Grain byproducts						
Brewers Dried Grains	0.4	2.5	1.0			1.0
Distillers Dried Grains			2.0			
Corn Gluten Feed	5.0	0.3	2.5			1.0
Hominy Feed	5.0		1.0	2.5		1.0
Wheat Middlings	10.0	10.0	10.0		10.0	10.0
Wheat Bran	10.0	10.0	10.0	10.0	10.0	10.0
Rice Bran				2.5	2.5	2.5
Other ingredients						
Suncured Alfalfa Meal (15%)		7.5		7.5	7.5	
Molasses	8.0	8.0	8.0	8.0	8.0	8.0
Urea	2.0	2.0	2.0	2.0	2.0	2.0
Dried Beet Pulp				5.0		
Dried Citrus Pulp						2.5
	100.0	100.0	100.0	100.0	100.0	100.0
Cost per hundred-weight	$5.14	$4.57	$4.51	$5.26	$5.03	$5.00
Relative Cost ($4.51 = 100)	114	101	100	117	112	109
Energy analysis						
BTU per hundred-weight	240,000	244,000	235,000	314,000	252,000	237,000
Relative energy (171,000 = 100)	140	143	137	184	147	139

Appendix Table 4. Least Energy 16% Dairy Rations for Specified Consumption Regions, 1976

Feed Ingredients	Northeast	Lake States	Corn Belt	Pacific	Southern Plains	Southeast
	pounds					
Feed grains						
Corn	49.0	58.4	52.4	3.9	49.5	59.3
Sorghum				25.0		
Barley	5.0			15.0	5.0	
Oats	7.5	7.5	7.5	2.5	5.0	2.5
Wheat			5.0	5.0	2.5	
Oilseed Meals						
Soybean Oil Meal (49%)	13.5	14.1	11.6	10.6	5.5	12.2
Cottonseed Oil Meal (41%)			2.5	5.0	10.0	2.5
Grain byproducts						
Hominy Feed	5.0		1.0	2.5		1.0
Wheat Middlings	10.0	10.0	10.0	10.0	10.0	10.0
Wheat Bran	10.0	10.0	10.0	10.0	10.0	10.0
Rice Bran				2.5	2.5	2.5
Other ingredients						
Molasses				8.0		
	100.0	100.0	100.0	100.0	100.0	100.0
BTU per hundredweight	198,000	185,000	178,000	229,000	171,000	196,000
Relative energy (171,000 = 100)	116	108	104	134	100	115
Cost analysis						
Cost per hundredweight	$5.62	$5.24	$4.96	$5.80	$5.95	$5.48
Relative cost ($4.51 = 100)	125	116	110	129	132	122

Appendix Table 5. Least Cost 32% Dairy Supplement Rations for Specified Consumption Regions, February 1976

Feed Ingredients	Consumption Region					
	Northeast	Lake States	Corn Belt	Pacific	Southern Plains	Southeast
	pounds					
Feed grains						
Corn	6.5	13.1	18.4			15.6
Sorghum				9.7	27.5	
Barley	5.0					
Wheat				5.0		
Oilseed Meals						
Soybean Oil Meal (44%)	40.9	43.9	44.8	47.0	39.6	46.2
Cottonseed Oil Meal (41%)					10.0	
Grain byproducts						
Brewers Dried Grains	2.5	2.5	1.0			1.0
Distillers Dried Grains	5.0		2.0			
Corn Gluten Feed	5.0	2.5	2.5			1.0
Hominy Feed	5.0		1.0	2.5		1.0
Wheat Middlings	10.0	10.0	10.0		10.0	10.0
Wheat Bran	10.0	10.0	10.0	10.0		10.0
Rice Bran				2.5	2.5	2.5
Other ingredients						
Suncured Alfalfa Meal (15%)		7.5		7.5		
Molasses	8.0	8.0	8.0	8.0	8.0	8.0
Animal Fat	0.1	0.5	0.3	0.8	0.4	0.1
Urea	2.0	2.0	2.0	2.0	2.0	2.0
Dried Beet Pulp				5.0		
Dried Citrus Pulp						2.5
	100.0	100.0	100.0	100.0	100.0	100.0
Cost per hundredweight	$6.06	$5.64	$5.25	$5.92	$5.90	$5.61
Relative cost ($5.25 = 100)	115	107	100	113	112	107
Energy analysis						
BTU per hundredweight	277,000	265,000	243,000	364,000	259,000	240,000
Relative energy (188,000 = 100)	147	141	129	194	138	128

Appendix Table 6. Least Energy 32% Dairy Supplement Rations for Specified Consumption Regions, 1976

Feed Ingredients	Consumption Region: Northeast	Lake States	Corn Belt	Pacific	Southern Plains	Southeast
	pounds					
Feed grains						
Corn	9.3	18.7	12.7		9.9	19.7
Barley	5.0			15.0	5.0	
Oats	7.5	7.5	7.5	2.5	5.0	2.5
Wheat			5.0	5.0	2.5	
Oilseed meals						
Soybean Oil Meal (49%)	53.2	53.8	51.2	49.5	45.1	51.8
Cottonseed Oil Meal (41%)			2.5	5.0	10.0	2.5
Grain byproducts						
Hominy Feed	5.0		1.0	0.3		1.0
Wheat Middlings	10.0	10.0	10.0	10.0	10.0	10.0
Wheat Bran	10.0	10.0	10.0	10.0	10.0	10.0
Rice Bran				2.5	2.5	2.5
Other ingredients						
Animal Fat			0.1	0.2	0.3	
	100.0	100.0	100.0	100.0	100.0	100.0
BTU per hundredweight	214,000	196,000	188,000	263,000	199,000	199,000
Relative energy (188,000 = 100)	114	104	100	140	106	106
Cost analysis						
Cost per hundredweight	$6.74	$6.58	$5.58	$7.08	$6.90	$6.52
Relative cost ($5.25 = 100)	128	125	106	135	131	124

Appendix Table 7. Least Cost 40% Beef Supplement Rations for Specified Consumption Regions, February 1976

Feed Ingredients	Consumption Region				
	Lake States	Corn Belt	Pacific	Southern Plains	Southeast
			pounds		
Oilseed meals					
Soybean Oil Meal (44%)	83.3	83.7	88.6	76.3	88.1
Cottonseed Oil Meal (41%)				10.0	
Grain byproducts					
Brewers Dried Grains	2.5	1.0			1.0
Distillers Dried Grains		2.0			
Corn Gluten Feed	2.5				
Hominy Feed		1.0			
Wheat Middlings	10.0	10.0		10.0	
Wheat Bran	0.7	1.4			
Rice Bran			2.5	2.5	2.5
Other ingredients					
Molasses			7.6	0.4	7.2
Animal Fat	1.0	0.9	1.3	0.8	1.2
	100.0	100.0	100.0	100.0	100.0
Cost per hundredweight	$6.69	$5.95	$6.62	$6.88	$6.32
Relative cost ($5.95 = 100)	112	100	111	116	106
Energy analysis					
BTU per hundredweight	249,000	235,000	393,000	248,000	260,000
Relative energy (199,000 = 100)	125	118	197	125	131

Appendix Table 8. Least Energy 40% Beef Supplement Rations for Specified Consumption Regions, 1976

Feed Ingredients	Consumption Region				
	Lake States	Corn Belt	Pacific	Southern Plains	Southeast
			pounds		
Feed grains					
Oats	5.7	4.0	2.2	1.2	2.5
Oilseed meals					
Soybean Oil Meal (49%)	73.8	71.9	70.0	65.9	71.8
Cottonseed Oil Meal (41%)		2.5	5.0	10.0	2.5
Grain byproducts					
Hominy Feed		1.0			0.4
Wheat Middlings	10.0	10.0	10.0	10.0	10.0
Wheat Bran	10.0	10.0	10.0	10.0	10.0
Rice Bran			2.5	2.5	2.5
Other ingredients					
Animal Fat	0.6	0.6	0.3	0.4	0.3
	100.0	100.0	100.0	100.0	100.0
BTU per hundredweight	205,000	199,000	309,000	220,000	202,000
Relative energy (199,000 = 100)	103	100	155	111	102
Cost analysis					
Cost per hundredweight	$7.29	$6.17	$7.68	$7.45	$7.06
Relative cost ($5.95 = 100)	123	104	129	125	119

Appendix Table 9. Least Cost 24% Broiler Starter Rations for Specified Consumption Regions, February 1976

Feed Ingredients	Consumption Region			
	Northeast	Pacific	Southern Plains	Southeast
	pounds			
Feed Grains				
Corn	52.7	39.5		45.2
Sorghum			38.6	
Oilseed meals				
Soybean Oil Meal (49%)	36.0	14.8	50.1	6.4
Soybean Oil Meal (44%)		34.9		34.2
Animal protein ingredients				
Fish Meal	2.5	2.5	2.5	2.5
Poultry Byproduct Meal	2.5		1.0	2.5
Grain byproducts				
Corn Gluten Meal	2.5			2.5
Other ingredients				
Animal Fat	3.8	8.3	7.8	6.7
	100.0	100.0	100.0	100.0
Cost per hundredweight	$6.99	$7.47	$7.66	$6.85
Relative cost ($6.85 = 100)	102	109	112	100
Energy analysis				
BTU per hundredweight	300,000	412,000	321,000	298,000
Relative energy (261,000 = 100)	115	158	123	114

Appendix Table 10. Least Energy 24% Broiler Starter Rations for Specified Consumption Regions, 1976

Feed Ingredients	Consumption Region: Northeast	Pacific	Southern Plains	Southeast
	pounds			
Feed grains				
Corn	19.2	17.7	27.4	24.8
Barley		9.5		
Oats	7.5			2.5
Wheat		5.0		
Oilseed meals				
Soybean Oil Meal (49%)	51.3	45.3	49.6	49.4
Cottonseed Oil Meal (41%)		5.0	7.5	2.5
Animal protein ingredients				
Fish Meal		2.5		
Poultry Byproduct Meal	2.5		1.0	2.5
Grain byproducts				
Hominy Feed	5.0	2.5		1.0
Wheat Middlings	10.0		2.0	4.8
Rice Bran		2.5	2.5	2.5
Other ingredients				
Animal Fat	10.0	10.0	10.0	10.0
	100.0	100.0	100.0	100.0
BTU per hundredweight	276,000	361,000	273,000	261,000
Relative energy (261,000 = 100)	106	138	105	100
Cost analysis				
Cost per hundredweight	$7.81	$8.07	$8.14	$7.53
Relative cost ($6.85 = 100)	114	118	119	110

Appendix Table 11. Least Cost 20% Broiler Finisher Rations for Specified Consumption Regions, February 1976

Feed Ingredients	Consumption Region			
	Northeast	Pacific	Southern Plains	Southeast
	pounds			
Feed grains				
Corn	66.1	54.8	13.9	58.3
Sorghum			40.0	
Oilseed meals				
Soybean Oil Meal (49%)	25.2	3.0	37.7	
Soybean Oil Meal (44%)		34.4		32.2
Animal protein ingredients				
Fish Meal	2.5	2.5	2.5	2.5
Poultry Byproduct Meal	2.5		1.0	2.5
Grain byproducts				
Corn Gluten Meal	2.5			0.3
Other ingredients				
Animal Fat	1.2	5.3	4.9	4.2
	100.0	100.0	100.0	100.0
Cost per hundredweight	$6.43	$6.90	$7.05	$6.33
Relative cost ($6.33 = 100)	102	109	111	100
Energy analysis				
BTU per hundredweight	289,000	403,000	304,000	284,000
Relative energy (245,000 = 100)	118	164	124	116

Appendix Table 12. Least Energy 20% Broiler Finisher Rations for Specified Consumption Regions, 1976

Feed Ingredients	Consumption Region: Northeast	Pacific	Southern Plains	Southeast
	pounds			
Feed grains				
Corn	23.3	21.4	30.9	28.9
Barley		9.1		
Oats	7.5			2.5
Wheat		5.0		
Oilseed meals				
Soybean Oil Meal (49%)	40.4	34.3	38.6	38.5
Cottonseed Oil Meal (41%)		5.0	7.5	2.5
Animal protein ingredients				
Fish Meal		2.5		
Poultry Byproduct Meal	2.5		1.0	2.5
Grain byproducts				
Hominy Feed	5.0	2.5		1.0
Wheat Middlings	10.0	7.7	9.6	10.0
Wheat Bran	1.3			1.6
Rice Bran		2.5	2.4	2.5
Other ingredients				
Animal Fat	10.0	10.0	10.0	10.0
	100.0	100.0	100.0	100.0
BTU per hundredweight	258,000	332,000	252,000	245,000
Relative energy (245,000 = 100)	105	136	103	100
Cost analysis				
Cost per hundredweight	$7.50	$7.82	$7.80	$7.23
Relative cost ($6.33 = 100)	118	124	123	114

Appendix Table 15. Least Cost 28% Turkey Starter/Grower Rations for Specified Consumption Regions, February 1976

Feed Ingredients	Consumption Region: Lake States	Corn Belt	Pacific
		pounds	
Feed grains			
Corn	35.9	31.5	32.9
Oilseed meals			
Soybean Oil Meal (49%)	24.2	46.7	
Soybean Oil Meal (44%)	34.4	17.1	62.3
Animal protein ingredients			
Fish Meal	2.5		2.5
Grain byproducts			
Brewers Dried Grains	2.5	1.0	
Distillers Dried Grains		2.0	
Hominy Feed		1.0	
Other ingredients			
Animal Fat	0.5	0.7	2.3
	100.0	100.0	100.0
Cost per hundredweight	$6.52	$5.87	$6.85
Relative cost ($5.87 = 100)	111	100	117
Energy analysis			
BTU per hundredweight	274,000	252,000	411,000
Relative energy (224,000 = 100)	122	113	183

Appendix Table 16. Least Energy 28% Turkey Starter/Grower Rations for Specified Consumption Regions, 1976

Feed Ingredients	Consumption Region		
	Lake States	Corn Belt	Pacific
		pounds	
Feed grains			
Oats	7.5	7.5	
Wheat			5.0
Oilseed meals			
Soybean Oil Meal (49%)	68.3	66.7	57.1
Cottonseed Oil Meal (41%)		2.5	5.0
Animal protein ingredients			
Fish Meal			2.5
Grain byproducts			
Hominy Feed		1.0	
Wheat Middlings	10.0	10.0	10.0
Wheat Bran	6.2	4.6	9.1
Rice Bran			2.5
Other ingredients			
Animal Fat	8.0	7.7	8.8
	100.0	100.0	100.0
BTU per hundredweight	229,000	224,000	323,000
Relative energy (224,000 = 100)	102	100	144
Cost analysis			
Cost per hundredweight	$7.95	$6.71	$8.30
Relative cost ($5.87 = 100)	135	114	141

Appendix Table 17. Least Cost 18% Turkey Grower/Finisher Rations for Specified Consumption Regions, February 1976

Feed Ingredients	Consumption Region: Lake States	Corn Belt	Pacific
	pounds		
Feed grains			
Corn	62.1	61.7	58.9
Wheat			5.0
Oilseed meals			
Soybean Oil Meal (44%)	24.9	31.5	28.9
Animal protein ingredients			
Fish Meal	2.5		1.7
Grain byproducts			
Brewers Dried Grains	2.5	1.0	
Distillers Dried Grains		2.0	
Corn Gluten Feed	2.5	2.5	
Hominy Feed		1.0	
Wheat Middlings	2.5	0.3	
Rice Bran			2.5
Other ingredients			
Molasses	3.0		3.0
	100.0	100.0	100.0
Cost per hundredweight	$5.39	$5.10	$6.08
Relative cost ($5.10 = 100)	106	100	119
Energy analysis			
BTU per hundredweight	264,000	250,000	369,000
Relative energy (207,000 = 100)	128	121	178

Appendix Table 18. Least Energy 18% Turkey Grower/Finisher Rations for Specified Consumption Regions, 1976

Feed Ingredients	Consumption Region		
	Lake States	Corn Belt	Pacific
		pounds	
Feed grains			
Corn	29.2	19.9	8.7
Barley			15.0
Oats	7.5	7.5	2.5
Wheat		5.0	5.0
Oilseed meals			
Soybean Oil Meal (49%)	35.9	35.4	27.3
Cottonseed Oil Meal (41%)		2.5	5.0
Animal protein ingredients			
Fish Meal			2.5
Grain byproducts			
Hominy Feed		1.0	2.5
Wheat Middlings	10.0	10.0	10.0
Wheat Bran	10.0	10.0	9.0
Rice Bran			2.5
Other ingredients			
Animal Fat	7.4	8.7	10.0
	100.0	100.0	100.0
BTU per hundredweight	211,000	207,000	277,000
Relative energy (207,000 = 100)	102	100	134
Cost analysis			
Cost per hundredweight	$6.77	$6.25	$7.61
Relative cost ($5.10 = 100)	133	123	149

Appendix Table 19. Least Cost 16% Swine Rations for Specified Consumption Regions, February 1976

Feed Ingredients	Consumption Region			
	Lake States	Corn Belt	Southern Plains	Southeast
	pounds			
Feed grains				
Corn	67.1	51.6	28.3	65.7
Sorghum		7.5	40.0	
Wheat			2.5	
Oilseed meals				
Soybean Oil Meal (49%)		11.9		
Soybean Oil Meal (44%)	17.5	2.0	10.9	17.0
Cottonseed Oil Meal (41%)			7.5	
Grain byproducts				
Brewers Dried Grains		1.0		
Distillers Dried Grains		2.0		
Hominy Feed		1.0		1.0
Wheat Middlings	10.0	10.0	10.0	10.0
Wheat Bran	5.4	10.0		1.7
Rice Bran			0.8	
Other ingredients				
Molasses		3.0		3.0
	100.0	100.0	100.0	100.0
Cost per hundredweight	$5.05	$4.77	$5.49	$5.32
Relative cost ($4.77 = 100)	106	100	115	112
Energy analysis				
BTU per hundredweight	203,000	205,000	223,000	222,000
Relative energy (179,000 = 100)	113	115	125	124

Appendix Table 20. Least Energy 16% Swine Rations for Specified Consumption Regions, 1976

Feed Ingredients	Consumption Region: Lake States	Corn Belt	Southern Plains	Southeast
	pounds			
Feed grains				
Corn	58.4	52.0	56.8	59.3
Barley			5.0	
Oats	7.5	7.5		2.5
Wheat		5.0	2.5	
Oilseed meals				
Soybean Oil Meal (49%)	14.1	11.7	8.2	12.2
Cottonseed Oil Meal (41%)		2.5	7.5	2.5
Grain byproducts				
Hominy Feed		1.0		
Wheat Middlings	10.0	10.0	10.0	10.0
Wheat Bran	10.0	10.0	10.0	10.0
Rice Bran				2.5
Other ingredients				
Animal Fat		0.3		
	100.0	100.0	100.0	100.0
BTU per hundredweight	185,000	179,000	183,000	196,000
Relative energy (179,000 = 100)	103	100	102	109
Cost Analysis				
Cost per hundredweight	$5.24	$4.99	$6.03	$5.48
Relative cost ($4.77 = 100)	110	105	126	115