Marketing Research Report No. 472

Impact of UREA On OILSEED MEAL MARKETS

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
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PREFACE

This report presents an economic analysis of the use of urea as a source of nitrogen for conversion to protein in feeds for ruminants, and the potential effect of its use on markets for farm-produced proteins.

The report neither states nor implies, directly or indirectly, that urea use in ruminant feeds is recommended or should be recommended by the United States Department of Agriculture. This is an economic analysis of a very complex subject. Information to show how the future market for agricultural products may evolve is vital to current marketing and production decisions. Knowledge about competition between agricultural and nonagricultural products fills an essential need. This report is designed to fill a part of that need.

The study was conducted under the general direction of Frederick J. Poats, agricultural economist, of the Market Development Research Division.

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UNITED STATES DEPARTMENT OF AGRICULTURE 1862 1962
Growth Through Agricultural Progress

May 1961

IMPACT OF UREA ON OILSEED MEAL MARKETS

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SUMMARY

Urea as a source of nitrogen for rumen synthesis of protein does not appear likely to replace natural proteins in mixed feeds in any substantial degree, judging from recent trends, new developments in feeding, and industry interviews. However, use of urea in mixed feeds for ruminant livestock is expected to increase relatively more in the next few years than use of natural proteins, but from a small base. Consumption is expected to rise from about 81,000 tons in 1959 to 125,000 tons in 1964, judging from trends in production of high-protein feed concentrates and use of urea in them. The sale of urea has been increased by the addition of mineral supplements to concentrates and by mixing urea with molasses or ethyl alcohol.

As a ruminant feed ingredient, the protein derived from urea generally costs less than protein in oilseed meal. Other factors, however, enter into ration determination. Natural proteins have strong advantages over urea; they are more palatable, contain minerals, provide energy in the ration, and generally are nontoxic to livestock, whereas urea, improperly used, may be toxic. The availability of farm-produced feed ingredients and the need to consume them also constitute an important factor in ration makeup by individual livestock raisers. These factors tend to forestall large or rapid increases in use of urea in feeds.

Three general grades of urea are manufactured for three major markets. The three grades are used in fertilizers, manufacturing (plastics, etc.), and animal feeds. Urea has been extensively evaluated as a feed ingredient in feeding trials since shortly before World War II. Commercial-scale use of urea in feed mixes began about 1950.

Urea use was equivalent, in protein nitrogen, to about 7 percent of the nitrogen in high-protein feed ingredients consumed by ruminants in 1958 and to about 8 percent in 1959. Urea use at about 125,000 tons in 1964 would be equivalent to about 10 percent of the projected level of protein ingredients fed to ruminants.

BACKGROUND

Nature of the Protein Feed Ingredient Market

Urea is a nitrogenous compound, $CO(NH_2)_2$, produced from carbon dioxide and ammonia, or from calcium cyanamide under heat and pressure. It has been the principal source of inorganic nitrogen used in mixed feeds. It is converted to protein in the rumens of beef and dairy cattle, sheep, and goats.

Oilseed meals have been, and, unless conditions change drastically, will continue to be the principal sources of protein for high-protein rations for ruminant livestock. Other sources of protein include meat scraps, tankage, brewers' and distillers' dried grains, and alfalfa meal. The great increase in production of oilseeds, particularly soybeans, creates a situation in which continued market maintenance and development are vital, to avoid serious economic problems of possible surpluses and lowered prices of farm-produced proteins.

Feed-grade urea contains about 42 percent nitrogen. Nitrogen from the compound is converted by microorganisms in the rumens of cattle, sheep, and goats into protein usable by the animals. 1/ As the microorganisms are digested in the alimentary tract, the protein derived from urea by these rumen bacteria become available for the ruminant to use for its own body. (10)

Urea alone does not provide feed energy, and it requires a relatively large quantity of carbohydrates, such as grain, to equal the energy in the protein feed displaced in feed mixes by its use. Therefore, in substituting urea for a 41 percent protein oilseed meal, 7 pounds of oil meal may be replaced by approximately 1 pound of urea and 6 pounds of cereal grains.

Increased knowledge of animal nutrition has focused more attention on the relationships between feed ingredients, rather than merely the proper quantity of each ingredient to be included in a balanced feed. This is illustrated by reference to amino acid balancing. Amino acids are the "building blocks" that make proteins. An animal may need 3 pounds of protein daily, yet animal and vegetable proteins in feeds vary in types and quantities of amino acids. Lack of an essential amino acid in a ration may have as serious consequences as a shortage of protein. Nutritional balancing is complex, as amino acids are supplied from various animal and vegetable sources with additional variations in content of total protein, digestible protein, fat, cellulose, and carbohydrate, as well as minerals and vitamins. Essentially, it is a problem of supplying the "right" protein to go with all other ingredients used in the feed ration. Balancing rations for optimum nutrition has become a job for specialists. This has enhanced the upward trend in consumption of formula feeds and in making of concentrates to be added to other ingredients available for custom grinding and mixing by local feed mills. The microorganisms in the rumen apparently convert the nitrogen from urea and other feed ingredients into the amino acids essential to the animal.

Most ingredients of high-protein feeds are byproducts of plant and animal products. If the feed market were the only market for most crops that yield feed ingredients of high-protein value, supply and price would be vastly different. Prices of many of the high-protein feed ingredients are dependent on a demand governed by other factors than their use in feed. Feed manufacturers find that prices of ingredients vary with only a partial relationship to their feeding value, but the feed mixers must buy ingredients for formula feeds on the basis of price per unit of feed value to keep the cost of their feeds as low as possible. Therefore, within limits, one protein material is frequently substituted for another.

1/ The factor for estimating conversion of nitrogen to protein equivalency is 6.25. Therefore, a pound of urea of 42 percent nitrogen content equals 2.62 pounds of protein, or, expressed in protein, urea is a 262 percent protein feed ingredient.

On a farm-price basis, from 1951 to 1959, the average annual price of soybean meal was 4.51 cents a pound, or about 2 cents higher than that of shelled corn. Corn is most frequently used with urea when the urea is used to replace oilseed meals. As the protein content of a ration is increased, the savings by using urea in a concentrate or mixed feed increases. However, the price of corn is not always, nor in all areas or circumstances, substantially lower than the price of soybean meal.

The price of urea usually remains stable at a particular f.o.b. or delivered price for a considerable time. In the spring of 1959, feed-grade urea was as low as 5.25 cents a pound, delivered. Ingredients containing natural protein, such as oilseed meals, gluten feeds, and brewers' and distillers' grains, vary in price daily, seasonally, by area, and according to shipping costs. Therefore, on a feed value basis, urea is not always more economical to use than other protein sources.

Making Urea for Feed

In 1957, over 64,000 tons of urea were marketed to feed mixers for use in feeds for ruminants, according to a report by the Department of Commerce (table 1). In terms of protein equivalent, urea consumption was equal to 6.7 percent of total high-protein ingredients used in feed mixing.

Table 1.--Urea production capacity, and production and distribution, calendar years 1956-60

Categories	1956 1/	1957 1/	1958 2/	1959 2/	1960 3/ 4/
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons
Capacity, end of year	N. A.	623	3/790	3/850	920
Production	424	488	530	630	660
Distribution, total	388	2/466	511	576	630
Fertilizer	181	2/243	345	413	470
Animal feed	3/ 53	2/ 64	75	81	85
Other industrial uses	3/154	2/159	91	82	75
Difference between production and distribution	3/ 36	22	19	54	30

1/ "Chemicals and Rubber," Business and Defense Services Administration, U. S. Department of Commerce, April 1958.
2/ "Synthetic Organic Chemicals," U. S. Tariff Commission annual report.
3/ Estimated.
4/ Does not include 30,000-ton-capacity plant in Calgary, Alberta, Canada, which began operation late in 1960. This firm markets feed grade urea in the northwestern U. S., as well as in Canada.

Urea manufacturing capacity through 1958 continued to exceed production by a substantial margin. In 1957, urea production was 80 percent of capacity; for 1960, it is estimated at only 72 percent of an expanded capacity (table 1).

Market development has been focused mainly on uses of urea for fertilizer and plastics. Urea for animal feed has received increasing attention, but the industry capacity prior to 1956 was utilized mainly for the fertilizer and plastics markets. Since 1956, the feed market has become more important in planning urea productive capacity. Production of urea in 1959 was 630,000 tons. Distribution by markets in 1959 was: 72 percent to fertilizer, 14 percent to industrial uses (mostly in plastics), and about 14 percent to feed.

Estimates of use indicate that fertilizer provides both the largest and fastest growing market for urea. The feed market for urea also is growing, and for 1960 it is estimated to exceed urea for "other industrial uses." Projected increases in use of urea for feed are less than estimated idle urea-making capacity for the present and immediate future. Therefore, increases in feed use will depend on market development rather than on potential availability of urea supplies.

ECONOMIC RELATIONSHIPS BETWEEN UREA AND NATURAL PROTEIN

Direct Comparison

Experimental feeding of urea can be justified on the basis of the cost of protein value from urea and from oilseed meals. When urea sells for $105 a ton and oilseed meal at $60 a ton, the estimated protein costs, after allowances for values other than protein, are:

	Cost/lb.	Protein value	Cost of protein equivalent/lb.
	Cents	Percent	Cents
Urea	5.25	262	2.00
Oilseed meal	3.00	44	1/ 4.70

1/ Estimated using meal containing the following analysis and values: fat 5% at 7¢ lb.; fiber 10% at 1/2¢ lb.; carbohydrate 29% at 2¢ lb.; moisture 12%, no value.

The differences in costs have been great enough to spur considerable research on the substitution of urea for natural protein sources. Two major factors determine the type of ration to be fed to cattle. These factors are:

(1) The purpose for which animals are being fed.- For example, cattle intended for (a) breeding, (b) long-term weight gain, or (c) quick gains to market weights require different feeds, with particular economic considerations. The feeding of heavy calves, stockers, yearlings, 2-year-olds, and range cows also presents different nutritional requirements.

(2) The availability of various feeding materials.- Since nutritional requirements can be met by using local or shipped-in feed materials, cost considerations become paramount. The cost of rations in relation to returns becomes the determinant in choosing the source of nutrients among ingredients for mixed feeds.

The variety of ration compositions and ingredient sources for feeding beef cattle makes it difficult to generalize as to the typical ration.

Cattle feeds are a substantial outlet for oilseed meals. Poultry and swine also consume large quantities of high-protein feeds. Proteins, as a whole, have always been more expensive than feeds of high carbohydrate value. The problem has been to achieve maximum rate of gain, per pound of feed, with lowest possible costs per pound of gain. This has led to continual research in animal nutrition to obtain a maximum production of meat with minimum inputs of protein. Feeding and animal nutrition research indicated that rumen bacteria are economical converters of non-protein nitrogen to protein. The most common source of this nitrogen for feeding beef cattle has been urea.

Dairy Ration Illustrated

Annual consumption of commercial high-protein feeds by dairy cattle exceeded that by beef cattle from 1951 to 1958. The economics of using urea or soybean meal in an assumed typical 14.5 percent protein dairy ration for lactating animals is used below to illustrate the general relationship of urea and corn, in contrast to soybean meal, as the protein source in mixed feeds for all ruminants.

The only ingredient change in making a 14.5 percent protein dairy ration with urea instead of soybean meal is that 1 pound of urea and 6 pounds of corn are used for every 7 pounds of soybean meal. If milk yields are unchanged by the change in a ration, the economics varies only by the relative cost of the urea-corn combination used to replace soybean meal.

The average farm price plus grinding cost for corn, and the price of soybean meal per pound, from the 1951 through 1959 feed years fluctuated considerably; the price of urea remained fairly stable. 2/ The cost of ground corn averaged 2.5 cents a pound from 1951 through 1959 and soybean meal 4.5 cents a pound (table 2). Urea is assumed to have been 6 cents a pound for the entire period.

The relationship of costs of a dairy ration using urea-corn and one using soybean meal is shown in figure 1. Use of urea and corn to replace soybean meal in the ration resulted in a saving. To determine which is cheaper, find the price for one ingredient, either corn or soybean meal, and determine at what price the other ingredient is lower in cost as a component of the ration. For example, when the price of corn is 2 cents a pound, a soybean meal price

2/ Price was assumed to be 6 cents a pound, since the fluctuation in price was less than 1 cent. Urea has the least effect on the total cost of these ingredients considered as variables.

Table 2.--Comparative costs per 100 pounds of mixed feed of a 14.5 percent protein dairy ration using soybean meal or urea-corn, 1951-59

Year beginning October 1	Corn for feed, average price paid by farmers 1/	Soybean meal, average price paid by farmers 2/	Cost of 12 pounds of: corn and 2 pounds of urea 3/	Cost of 14 pounds of: soybean meal	Difference in ration cost per 100 pounds using urea-corn or soybean meal
	Cents/lb.	Cents/lb.	Cents	Cents	Cents
1951......	3.11	5.44	49.3	76.2	26.9
1952......	2.86	4.99	46.3	69.9	23.6
1953......	2.79	5.28	45.5	73.9	28.4
1954......	2.70	4.50	44.4	63.0	18.6
1955......	2.56	4.10	42.7	57.4	14.7
1956......	2.45	3.84	41.4	53.8	12.4
1957......	2.13	4.08	37.6	57.1	19.5
1958......	2.15	4.26	37.8	59.6	21.8
1959......	2.06	4.12	36.7	57.7	21.0
1960 4/...	1.82	3.90	----	----	----
9-yr. mean: price...	2.54	4.51	42.4	63.2	20.8

1/ Calculated from price received per bushel by farmers in the United States, Grain and Feed Statistics, Supplement for 1958, 1951 and 1952; Supplement for 1959, 1953-59, plus an estimated cost of grinding of .15 cent a pound.
2/ Calculated from Grain and Feed Statistics, Supplement for 1958, 1951-52, and Supplement for 1959, 1953-59.
3/ Cost of urea assumed to be 12 cents for 2 pounds for entire period.
4/ 4-month average.

Table 2A.--Ingredients per 100 pounds of a 14.5 percent protein dairy ration using urea or soybean meal

Ration ingredients	Soybean meal	Urea-corn
	Pounds	Pounds
Corn......................	50	62
Oats......................	25	25
Bran......................	10	10
Salt......................	1	1
Soybean meal..............	14	--
Urea......................	--	2
Total.....................	100	100

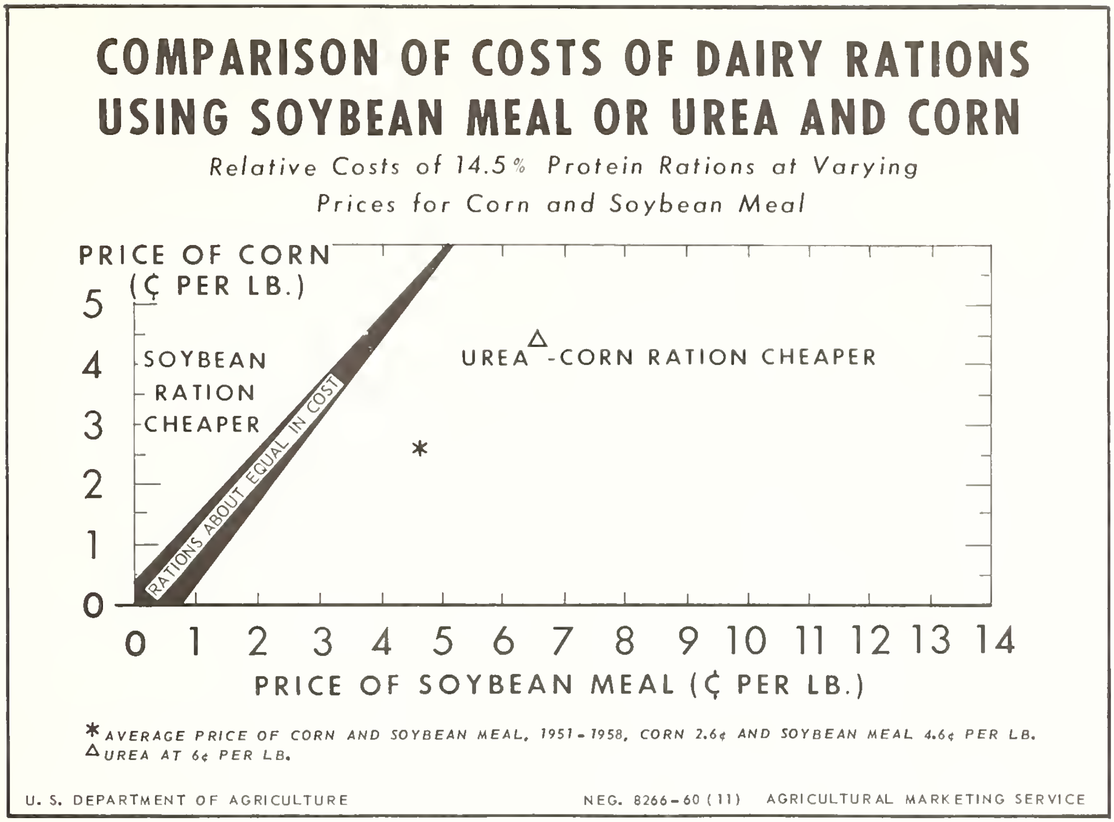

Figure 1

of 2-1/2 cents a pound or more would make it more economical to use urea and corn to replace soybean meal. Contrarily, with a price of 2 cents a pound for soybean meal and corn over 2.3 cents a pound, it would be cheaper to use soybean meal. 3/

Cattle feeding is not as simple as illustrated, when all factors concerning economics of feed mixing and nutrition are considered.

Beef Cattle Ration Illustrated

A wintering ration using urea and one using soybean meal are compared in table 3. The data do not represent an actual feeding experience; they do illustrate the economic advantage of urea in relation to soybean meal or other oilseed meals as the price of soybean meal is increased relative to the price of molasses, corncobs, and urea. The United States average price paid by farmers for soybean meal from 1951 through 1959 was 4.51 cents a pound.

3/ The shaded area on the chart covers price levels where soybean and corn-urea ration ingredients are about equal.

Table 3.--Feed cost of winter ration for cattle using soybean meal, molasses, and corncobs, as compared with urea, molasses, and corncobs 1/

Feeds	Feed per 100 pounds of gain		Price per pound	Cost per 100 pounds of gain			
					Soybean ration, when soybean meal costs, per pound--		
	Urea ration	Soybean ration		Urea ration	2 cents	3 cents	4 cents
	Pounds	Pounds	Cents	Dollars	Dollars	Dollars	Dollars
Corncobs......	1,220	1,130	0.5	6.10	5.65	5.65	5.65
Soybean meal........	---	174	---	----	3.48	5.22	6.96
Molasses......	211	77	1.5	3.16	1.15	1.15	1.15
Bonemeal......	14	14	5.0	.70	.70	.70	.70
Salt..........	5	5	1.5	.08	.08	.08	.08
Urea..........	26	---	6.0	1.56	---	---	---
Minerals and vitamin A...	3	---	5.0	.15	---	---	---
Total.......				2/12.37	11.06	12.80	14.54

1/ Rations selected to illustrate possible savings, not a ration now popular. If urea constitutes more than one-third of the protein in a ration, most feed control laws require at least a warning about possible toxicity.

2/ The two feeds are roughly equivalent in protein and energy values. It has been found that the gain from urea is somewhat less than the gain from soybean rations in the same feeding period. The cost of urea ration has been raised by a factor of 1.053.

PRODUCERS' AND DISTRIBUTORS' VIEWS ON UREA IN FEEDS

Feed Manufacturers' Views

Four manufacturers of feed-grade urea and 43 firms producing mixed feeds for ruminants were interviewed during the spring of 1959.

All of the feed mixers interviewed who were producing ruminant feeds and who produced over 50,000 tons of feed a year used some urea. Firms producing less than 50,000 tons of feed a year gave various reasons for using or not using urea.

The major reasons given for not using urea in feeds were (1) local farmers did not want an inorganic ingredient to replace oilseed meal in their cattle feed, (2) other sources of protein were available locally at what were considered to be competitive prices, (3) handling urea increased mixing costs and problems, (4) the savings that might accrue from using urea were not worth the extra problems involved, and (5) the mixers felt that a marketing stigma was attached to cheap feeds, and urea is often used only in the cheapest feeds. Other problems cited were labor costs, control of feeding levels, and facilities needed to accommodate the handling of urea.

The feed-making firms as a whole did not foresee in the immediate future any significant change in the percentage of urea used in relation to other sources of protein. They considered that further growth in use will be directly related to the volume of production and sale of the higher protein feeds for ruminants, rather than to increases in percentage of protein equivalent from urea in feeds.

A large Midwestern feeder and feed manufacturer viewed the growth in future use of urea on more positive terms. He stressed the economic advantage of urea and minimized the danger of toxic effects. He said the cost of a beef cattle ration of 10 percent protein using urea-molasses is $20 per ton less than feeds containing natural proteins. This ration also required vitamin A, corncobs, and minerals. In this ration, urea is not limited to one-third of the protein. Furthermore, the urea-molasses mix is self-fed with good results. For this analysis, ingredient costs were calculated as follows:

Cattle Ration: Costs of Ingredients

Carbohydrate or equivalent		Protein or equivalent	
	Dollars per ton		Dollars per ton
Sugar (molasses).........	50	Oilseed meals........	94
Starches.................	40	or	
Cellulose................	5	Urea.................	40

A "typical ration," according to the feeder quoted, includes 90 percent carbohydrate, 10 percent protein. The following ingredients are added when corncobs (cellulose) and urea are used to replace oilseed meals in a ration:

(1) A "fast" carbohydrate - molasses or other carbohydrate materials are used to stimulate microorganism activity in the rumen.

(2) Proper minerals - supplemental calcium and phosphorus are used, as molasses contains only traces of these and urea none.

(3) Vitamin A - an essential vitamin when cattle are not receiving fresh forage or oilseed meal.

This livestock feeder contemplates a much greater potential use of urea than other respondents to our survey.

Price differences effective over long periods of time determine feeds used. Manufacturers did not consider the soybean and urea-corn price ratio as vital in the use of urea. This belief was based upon the fact that urea is complementary to soybean meal in some mixes, as well as being competitive. Feed-mixing firms generally indicated that the urea used is replaceable by natural protein sources only to the extent that protein levels of feed-mixing concentrates can be reached by natural materials. Having urea available makes it possible to produce concentrates with higher protein equivalents than is possible with natural protein feeds. Therefore, some very high-protein concentrates (above 45 percent) could not be manufactured without urea.

In addition to State feed control laws restricting use of urea to one-third of the protein equivalent content of a final feed, and local conditions that offset the apparent economic advantage of using urea, feed-mixing firms mentioned these other factors as important in limiting use of urea:

(1) The feeding problem for ruminants varies by type of livestock. Supplements for dairy and beef cattle provide the largest volume markets for feed-grade urea. Sheep use only a small amount of feeds containing urea.

(2) The ability, through microorganisms, of dairy and beef cattle to make appropriate use of urea is influenced by animal age and by relative proportions and kinds of proteins and carbohydrates in the ration. In various feeding experiments, it has been demonstrated that sulfur and various amino acids supplement and also contribute to the effective utilization of urea as a feed ingredient.

(3) Liquid feeds containing urea with other ingredients, such as ethyl alcohol and molasses, are not always economic to handle. Their use requires expensive equipment to proportion and mix the ingredients properly, and it adds to the equipment investment. The increased cost is justified only when a large volume of feeds is mixed.

Urea Manufacturers' Views

A slightly different process is used in producing urea for feed than for fertilizer and plastics. Therefore, the supply of urea for feed is governed by manufacturers' estimates of demand for feed-grade urea. Commercial use for feeding has continued to increase as actual feeding experiences have indicated that a lower cost of production can be achieved with urea.

The urea-corn replacement of oilseed meal in rations for ruminants is generally economically feasible for large-volume feed mixers and large feedlot operations. Smaller operations may be accompanied by other factors which offset the possible savings in ingredient costs. Oilseed meals usually cost substantially more than corn, however, and this favors continued experimentation with urea-corn substitution.

Urea manufacturers have recognized three nutritional "barriers" to greater use of their product. These are problems connected with energy balance in feeds, palatability of urea, and some possible toxic effects of improper use of urea. Nutritional research on the "barriers" to use of urea continues. For example, it has been found that energy balance in the feed can be obtained more cheaply using urea with other ingredients than oilseed meals, such as fats or molasses.

Also, the use of fillers in urea to prevent caking has improved handling. A reduction in the size of crystals of urea has aided dispersion in dry feeds and solubility in molasses.

The palatability problem is principally connected with feeding dairy cattle. Sustained milk production involves a more delicate feeding operation than maintenance and fattening of beef cattle. The use of urea in all cattle feeding requires that the animal adjust to different feeds.

PRESENT AND POTENTIAL USE OF UREA

Feeding Problems and the Future

Innovations resulting from research will be the determining factor in any major change in the prospective use of urea in ruminant feeds. Without significant additions to our knowledge of cattle feeding, consumption of urea is not likely to rise substantially. Dr. C. F. Huffman of the Michigan State University reminds us that until scientists learn all about what happens in the rumen, the nutritive value of various roughages cannot be reliably told. Techniques used in determining the amounts of volatile fatty acids in rations for cattle can account for only about 50 percent of the net energy they receive. Just how they obtain the rest remains a mystery. (9) Additional research may lead to the discovery of ways to substitute more nitrogen from nonprotein sources in ruminant feeds and to achieve higher feed energy yields when urea is fed.

The problems of palatability and energy balance also are being researched. Two of the materials being studied are liquid urea-alcohol mixtures and urea-molasses mixtures. Both alcohol and molasses are designed to improve the feed efficiency and the palatability of ruminant-type feeds. The claims for urea-alcohol mixtures are not consistent for all research results. The contrast is as follows:

Claimed benefits derived from urea (1)	Other observations about feeding alcohol and urea
1. More rapid weight gain per unit of feed.	Variation in weight gain per unit of feed in each experiment is significant. Good and poor results indicate the importance of other variables in feeding. (3)
2. Conversion of more feed per day in the rumen of the animal.	Efficiency is measured in pounds of gain per pound of feed. Feed in the rumen must be converted to meat to be of economic significance.
3. Consumption of large portions of cheaper, high-cellulose roughages.	Roughages are not as cheap and available in all producing areas as commonly believed when feeding efficiency is calculated. The use of such feed mixtures as urea with poor-quality roughages has usually resulted in poor performance by the animal. (2)
4. Better quality meat.	There is little definite research on this point. Many believe urea-fed cattle do not produce meat of as good quality as other cattle produce. Most urea-fed cattle are given a fattening ration before marketing.

It is possible that future experiments and improvements in feeding practices will narrow the apparent gap between claims and practice. Purdue scientists recently reported on an experiment in which they added lysine to urea supplements. Many experiments have been run without considering lysine content, since all the essential amino acids can apparently be synthesized in the rumen by microorganisms from nonprotein nitrogen. The increase in feed efficiency and daily gain when using lysine with urea indicated that lack of lysine is apparently one of the limiting nutritional factors in the use of urea by cattle. (6) More critical research will probably be undertaken in the future. Judging from past events, the growth in use of urea for ruminant feeding after 1964 will be largely determined by results of future feeding research and practices.

Market Growth, 1956-59

Consumption of commercial high-protein feeds by ruminants from the 1956-57 feeding year (October-September) to 1959-60 increased about 5.6 percent to an estimated 5,402,000 tons (table 4). Consumption in 1959-60 was lower than that of the 1958-59 feeding year due to a drop in commercial high-protein feeds fed to beef cattle. Estimated urea consumption in the 1960 calendar year was about 33 percent greater than that consumed in 1957, or an estimated 85,000 tons. This increase in urea of about 21,000 tons is equivalent to about 112,560 tons of oilseed meal. The increase in use of urea is equal to less than half of the estimated total increase in commercial high-protein feeds fed to ruminants.

Feed and urea manufacturers agree that some high-protein mixed feed concentrates could not be made without urea. This is especially evident for

Table 4.--Consumption of commercial high-protein feeds, by kinds of livestock 1948-58, and estimated for 1959

Year beginning October 1	Dairy cattle	Beef cattle	Sheep	Total for ruminants
	1,000 tons	1,000 tons	1,000 tons	1,000 tons
1948	2,776	1,300	65	4,141
1949	2,671	1,502	64	4,237
1950	2,698	1,720	65	4,483
1951	2,598	1,985	70	4,653
1952	2,730	1,870	70	4,670
1953	2,748	1,925	75	4,748
1954	2,648	1,965	75	4,688
1955	2,784	2,035	75	4,894
1956	2,869	2,175	70	5,114
1957	2,926	2,365	70	5,361
1958	2,895	2,698	80	5,673
1959	2,909	2,411	82	5,402
1960 1/	---	---	--	5,200

1/ Estimated.

Farm Economics Research Division, Agricultural Research Service, U. S. Department of Agriculture.

concentrates of 40 percent or more protein. Manufacturers therefore estimate that 90 percent of the urea used can be considered as a direct substitute for other protein source materials.

In a mixed feed, a pound of urea is equivalent to about 5.36 pounds of oilseed meal. The use of 85,000 tons of urea is thus equivalent to 455,600 tons of 44 percent protein oilseed meal. Urea use is therefore equivalent to about 8 percent of the 1959-60 feed year consumption of commercial high-protein feeds by ruminants.

High-Protein Feed Market Growth, 1960-64

The "Chemical Forecast, 1964" which appeared in the September 1959, Oil, Paint and Drug Reporter estimated urea consumption in 1964 at 1,025,000 tons. Consumption in feed was estimated at 144,000 tons, about 14 percent of the total. The estimated consumption of urea for 1960 was 660,000 tons, with about 14 percent in feeds, or 92,500 tons. The increase in feed use from 1960 to 1964 represents a growth equivalent to 51,500 tons of urea, or about 277,000 tons of oilseed meal.

Another estimate of consumption in 1964 can be derived by assuming that the growth in the use of urea will do no more than parallel the growth in all high-protein feed consumption by ruminants.

This growth rate would require a total increase of only 10,000 tons of urea from 1960 to 1964. A 1964 consumption of 95,000 tons would be equivalent to about 509,000 tons of oilseed meal of 44 percent protein.

Whether the high projection of 144,000 tons or the low projection of 95,000 tons of urea for feed use in 1964 is more nearly achieved will depend on the resolution of problems of urea utilization as a feed ingredient.

Two factors will tend to increase the use of urea in feeds at a faster rate than the growth in use of protein feedstuffs for ruminants. These factors are the prices of urea and carbohydrates relative to natural proteins, and greater understanding, through nutrition research, of toxicity problems with urea. These factors, however, probably will restrict the growth in use of urea for feed to a lower rate than the increase in production of urea anticipated for fertilizer and industrial uses.

Consideration of all factors leads to an estimate no higher than 125,000 tons of urea in feeds in 1964. This estimate indicates that future research and economic developments will not enhance the value of urea as a feed ingredient at the expense of other ingredients. The growth in use of urea, as a direct displacement of oilseed meals for ruminant feeds, is expected to be small.

The following eventualities could increase urea consumption beyond the estimated 125,000 tons:

(1) Increased demand for very high-protein feed-mixing concentrates which will require urea to achieve protein equivalents above 50 percent.

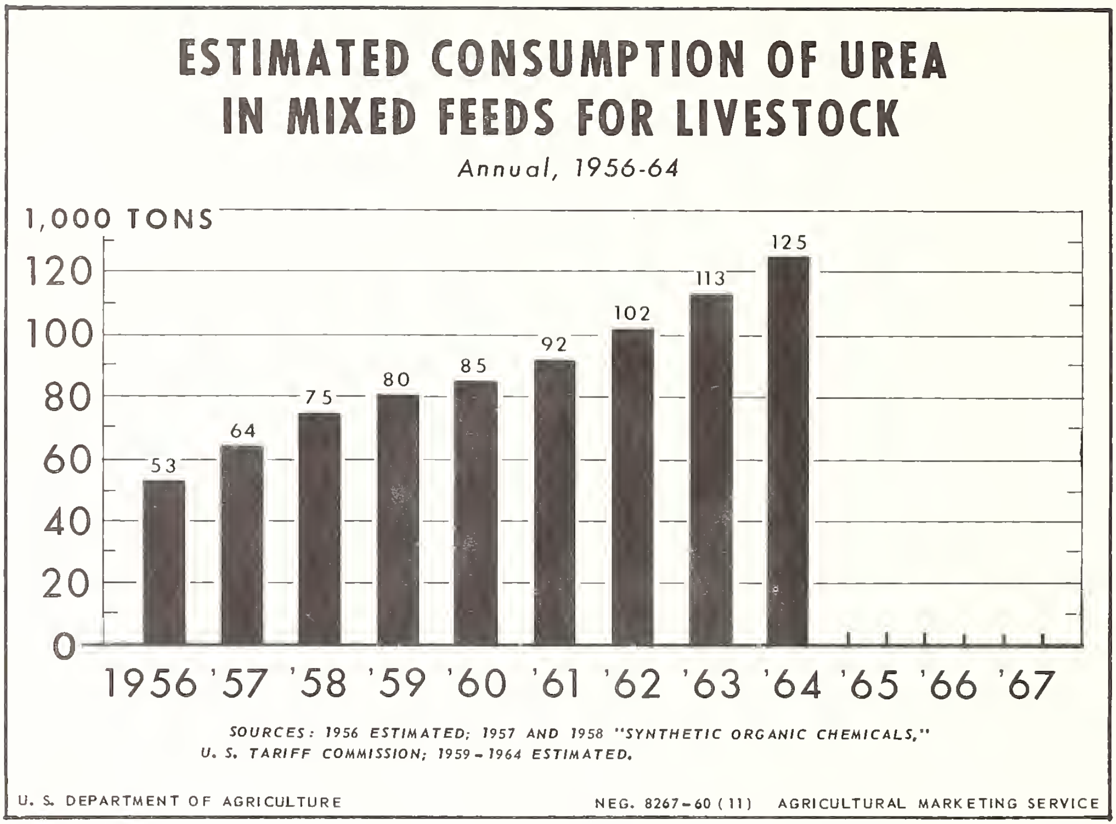

Figure 2

(2) A decline in the average price for beef cattle relative to the price of protein feedstuffs.

(3) Lower prices of corn relative to prices of oilseed meals.

The eventualities listed are not the only factors which could increase urea use beyond the volume estimated for 1964.

Factors which would tend to restrict urea use in 1960-64 are:

(1) Continued rapid increase in supplies of oilseed meals.

(2) The U. S. in 1958, 1959, and again in 1960 has been exporting record quantities of soybeans and large quantities of soybean meal. A reduction in exports could depress prices of soybeans and soybean meal.

SOME OTHER FACTORS

A cattle feed supplement of 80 percent molasses, 6 percent ethyl alcohol, 10 percent urea, 4 percent phosphoric acid, and trace minerals has been successfully fed by researchers at the University of Arkansas. (8) Results of these studies show that urea with molasses can be used as a protein supplement in larger amounts than the usual one-third of the total protein equivalent. (11)

Drylot operations by researchers at Texas Agricultural and Mechanical College with yearling, open, pregnant, and lactating ewes utilizing a urea-molasses mix, phosphoric acid, vitamin A, and trace minerals, as well as several types of low-quality roughage, proved that sheep could be successfully self-fed the urea supplement. (13) If verified in continued experiments, these findings may increase the competitive use of urea in supplements for sheep.

The range of choices possible for feed ingredients results in a great number of "profitable" rations for beef cattle. Their profitability depends not only on the cost of oilseed meals in relation to urea, but also on the cost and nutritional value of other ingredients available. Some supplements, compounded for economic gain, do not completely substitute urea for oilseed meal. The savings over more conventional oilseed meal rations may be $2 to $10 per ton of feed. (14) Such a feeding trial using linseed meal supplements and urea-oilmeal supplements for fattening cattle also indicated a feed cost reduction. (5)

The recent feeding trial results cited above imply that urea may be more satisfactory than is indicated in this report. However, in many previous feeding trials urea did not appear to be as satisfactory or economic.

Some current feeding trials are stressing the use of urea in conjunction with carbohydrates, cellulosic feeds, and feed additives. It is possible that better means may be found to feed urea, carbohydrates, and cellulosic materials to ruminants. But it is doubtful that urea with additives will replace great quantities of oilseed meals in the foreseeable future. Nevertheless, as long as research is applied to obtain greater livestock production from a given quantity of feed, scientists will evaluate urea.

One of the problems in comparing rates of gain from urea and other protein-based feeds is the quality of cattle fed. A good daily rate of gain cannot be obtained with the best ration if the cattle being fed are not basically good converters of feed to meat. It is axiomatic that scrub animals are not the top converters of feed to meat. Response to a urea ration by scrub animals will usually be poor.

Many feeding trials conducted with urea over the past 40 years did not show urea to be beneficial. However, there has been a gradual increase in urea use in the United States despite this. This may be explained by varying responses of cattle to diets. Cattle responses to diets vary by sex, drylot or pasture feeding, growing or fattening rations, types of grain fed, length of feeding period, disease level, and environment. (6) This indicates that varying results with cattle feeding trials in the future can be anticipated. Feeders, on the other hand, attempt to use urea only under conditions found most favorable from the many experiments previously run.

Urea is a more difficult feed ingredient to handle than oilseed meal for cattle, sheep, and goats. Nevertheless, the potential economic possibilities are attractive enough for feed manufacturers and scientists to continue to investigate urea when engaged in feed efficiency and nutrition studies.

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