SOURCES OF NON-PROTEIN NITROGEN IN STEER FINISHING RATIONS

by

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B. S., Kansas State University, 1965

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Husbandry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1967

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INTRODUCTION

Ruminant animals have several advantages over simple stomach animals. One is the protein synthesizing ability of rumen microorganisms. Rumen microorganisms utilize the ammonia from non-protein-nitrogen compounds to synthesize amino acids and build their body protein. After the bacteria are digested in the intestinal tract, the bacterial protein becomes available to the animal. The use of non-protein-nitrogen products is primarily limited to the amount that the rumen microorganisms can convert to microbial protein.

Urea is the primary non-protein-nitrogen product in use at the present time. It has its drawbacks, such as high ammonia production in the rumen, fast absorption from the rumen and poor palatability. A product which could maintain a more uniform supply of ammonia in the rumen and overcome the above objections would be well received. One such product may prove to be diammonium phosphate (DAP).

The economics of urea utilization in beef cattle rations are not as simple as they may appear at first. One factor to consider is the toxic effect if fed in too large a quantity. Normally, up to about one-third of the protein equivalent in rations may be supplied by urea. The level of urea in finishing rations for beef cattle can vary widely, depending on the ration used. These rations may range from high grain with limited roughage to high corn silage.

Ruminants usually utilize non-protein-nitrogen poorly when it is first placed in the feed. There seems to be a definite adjustment period before a ruminant makes best use of it in the ration.

Some suggestions for optimum utilization of non-protein-nitrogen products are: (1) readily available source of energy which can be supplied by molasses or grain particularly at the time ammonia is produced in the rumen; (2) adequate levels of mineral and vitamin supplementation are necessary; (3) some natural protein which may influence the utilization of other nitrogen sources; (4) thorough mixing of the supplement or ration; (5) the ration or supplement should be blended in such a way that sifting or sorting of ingredients does not occur.

Since DAP has been used widely as a nitrogen and phosphorus source in commercial fertilizers and it could be priced competitively with urea and phosphorus as a feed ingredient, there seemed to be a need for further studies to determine its feeding value for ruminants.

This experiment was designed to evaluate supplements containing: (1) all natural protein (soybean meal and dehydrated alfalfa); (2) part natural protein and part non-protein-nitrogen; and (3) non-protein-nitrogen without soybean meal in beef cattle finishing rations.

REVIEW OF LITERATURE

Historical

Armsby (1911) reviewed the literature on the synthesis of protein from non-protein-nitrogen compounds in the alimentary canal of animals and concluded: (1) that monogastric animals cannot utilize non-protein-nitrogen compounds for the synthesis of protein, and (2) protein synthesis in ruminants can be demonstrated.

Hart *et al*. (1939) showed that rations low in protein are inadequate for growth of calves and are effectively supplemented by urea.

Toxicity Levels of Various Non-Protein-Nitrogen Sources

With the onset of the use of urea as a source of non-protein-nitrogen in ruminant rations, much work was done on toxicity levels of various non-protein-nitrogen compounds. Ammonia toxicity is commonly called urea toxicity or urea poisoning.

Repp *et al*. (1955) used a stomach tube to administer a solution of urea to lambs and tested the blood ammonia values and toxicity levels. They reported that blood ammonia values were at a maximum at about 30 minutes after drenching. No clinical symptoms of toxicity occurred until the blood ammonia nitrogen level rose to about 1,000 mcg per 100 ml. Blood ammonia values and the dose level of the toxic non-protein-nitrogen compound showed a high degree of association. Symptoms of fatal toxicity were removed when acetic acid was administered orally, probably due to it neutralizing the ammonia.

Symptoms of ammonia toxicity reported by Davis and Roberts (1959) were uneasiness, rapid breathing, muscle tremors, slight incoordination, progressing to severe incoordination especially in the front legs and labored breathing. Bloat was always present with ammonia toxicity. Death usually occurred one and one-half to two and one-half hours after the onset of the symptoms. He observed that if a bloated animal was given a five per cent acetic acid solution it would generally recover.

Lewis (1960) used eight sheep fitted with permanent rumen fistulas to study ammonia toxicity. He stated that toxicity was brought about by fixation of ammonia in brain tissue and noted symptoms similar to those reported by Davis and Roberts (1959). These symptoms according to Lewis could arise due to: (1) direct toxic effect of the ammonium ion in the peripheral blood, (2) changes in acid base electrolyte balance of the body fluid and (3) toxicity of the carbonate ion. He observed that sheep blood ammonia nitrogen levels were higher than in non-ruminants. In the presence of urea, the changes in the acid base balance did not account for the toxicity.

Russell _et al_. (1961) used lambs to test the toxicity of various levels of urea and diammonium phosphate (DAP). The solution was administered via stomach tube. The toxicity of the two compounds was compared on a nitrogen equivalent basis. Ammonia toxicity with urea was observed at the level of 15 g per 100 lb body weight and it increased sharply at 30 g per 100 lb body weight. No toxicity occurred with DAP up to 40 g urea equivalent per 100 lb body weight. One lamb survived a dose of DAP equivalent to 75 g of urea. At a level of 40 g urea equivalent per 100 lb body weight, DAP was toxic when infused directly into the rumen. At this level the rumen pH increased from 6.8 to 8.1 within one-half hour after administration of urea; an equivalent amount of DAP caused an increase from 7.0 to 7.2 in the same time interval.

A highly significant difference was observed for the blood ammonia nitrogen of lambs receiving urea or DAP. Maximum blood ammonia nitrogen post urea dosage was 420 mcg per 100 ml per gram urea equivalent per 100 lb body weight while maximum blood ammonia nitrogen was 17.6 mcg per 100 ml per gram urea equivalent per 100 lb body weight following DAP dosage. Nitrogen retention was not significantly different between lambs receiving the two compounds.

The following year Russell et al. (1962) conducted further tests to obtain additional information about the possible toxicity of DAP and urea to lambs and steers. They also tested the utilization of DAP nitrogen by lambs. The compounds were given on the basis of nitrogen equivalent units, one unit equalling one gram urea or two and two-tenths grams DAP per 100 lb body weight. Results were similar to those observed the previous year. Direct infusion of 40 units of DAP into the rumen of lambs resulted in acute distress in 10 minutes after dosing and death 20 minutes post feeding. Lambs receiving 50 units of DAP died within 10 minutes after infusing the compound. The maximum blood ammonia nitrogen rise per unit of urea averaged 51 mcg per 100 ml with a corresponding value of 18 mcg for DAP. This was significantly different. Slower absorption of DAP nitrogen may be due to its lower pH, since the phosphate acts as a buffer. The lower pH may also be accounted for by the slower release of ammonia from DAP. This will cause a greater efficiency in nitrogen utilization.

On an isonitrogenous basis Oltjen et al. (1963) found DAP less toxic than urea when fed to sheep. Forty grams urea equivalent of DAP per 100 lb body weight were required to cause death and only 25 g of urea per 100 lb body weight are required. A smaller rise in rumen pH was observed with DAP than with urea. Data indicated that 88 g of DAP (equivalent to 40 g of urea) per 100 lb body weight was toxic to sheep.

Johnson and McClure (1964) reported that peak blood urea values seemed to occur somewhere between five and seven hours post feeding with both DAP and urea.

Digestibility Trials

Work reported by Rusoff _et al_. (1962) showed no significant difference in digestion coefficients between a control ration containing steamed bone meal and the experimental ration containing urea-phosphate and oyster shell flour.

Johnson and McClure (1963) conducted digestion trials with sheep fed a ration of corn cobs, soybean flakes, starch, ground shelled corn, minerals and vitamins A and D. The ration was supplemented with urea, biuret or DAP. A basal ration of 50:50 roughage to concentrate was used. They found that urea was utilized more efficiently than biuret or DAP.

Richardson and Tsien (1963) observed that rumen liquor of steers supplemented with soybean meal (SBM) contained substantially more amino acids than that obtained from steers fed urea.

Oltjen _et al_. (1963) reported that neither the dry matter nor the organic matter of a ration containing DAP was digested as well as rations containing SBM or urea. They observed that urinary nitrogen losses were greater in sheep fed DAP, and the nitrogen retention was therefore greater in sheep fed the urea and SBM rations. Differences, however, were not significant.

Johnson and McClure (1964) studied the digestibility and utilization of nitrogen from rations supplemented with urea, biuret or DAP. It was observed that nitrogen retention for the urea supplemented ration was significantly more than for the rations containing DAP or the basal ration.

Work reported by Schaadt et al. (1964) showed that DAP had a lower biological value than urea or biuret. Average nitrogen balance over the entire period was negative for DAP but positive for urea and biuret.

Schaadt et al. (1966) used four lots of six wether lambs for feeding and metabolism trials to test rations containing a mixture of DAP plus urea, urea and biuret. He reported that the DAP plus urea mixture had a significantly (p .05) lower biological value than that of the urea or biuret rations. There were no significant differences between treatments on digestibility of dry matter, cellulose, and organic matter, or rate of gain.

Richardson et al. (1966) using fistulated steers, tested DAP monammonium phosphate (MAP), a blend of MAP-urea and a blend of MAP-DAP, and determined ammonia production, total nitrogen and protein nitrogen in rumen ingesta. The products were tested at a level of 10 percent of the supplement, supplying 91 g per head daily. A blend of urea and dicalcium-phosphate was included in this test. These products made up approximately one-third of the total crude protein in the supplement except for MAP which furnished a lower level. The basal ration consisted of 2.72 kg, ground corn; 2.72 kg, prairie hay; and 0.91 kg of the supplement.

Ammonia production reached a peak within one-half hour after feeding except for the control (SBM) and the MAP-urea blend; but, no large differences were observed. The percent true protein of the crude protein was similar for all products tested. However, DAP and MAP-DAP tended to show less true protein in the rumen ingesta for the first four hours. There was a tendency for these products to release ammonia relatively slower.

McClure and Johnson (1966) studied the effect of coated and modified DAP products. Preliminary studies were used to determine rate of ammonia release from these products in aqueous suspension and their ability to serve as a sole source of nitrogen for in vitro rumen fermentations. A "Lactic acid ester" coated DAP (LADAP) product and two modified DAP materials satisfied the criteria best. No significant differences were observed when the rations were compared in digestion trials.

Karr et al. (1965) speculated that improved use of urea nitrogen could be made by (1) reducing the rate of urea hydrolysis in the rumen or converting urea to a less soluble form, (2) increasing the activity of rumen microorganisms to utilize available ammonia nitrogen, (3) increasing tissue utilization of ammonia nitrogen and (4) increasing the amount of urea nitrogen recycled to the rumen.

Palatability of Various Nitrogen Sources

Oltjen et al. (1963) compared the palatability of DAP to urea and SBM, and found that when DAP was fed in a meal form the sheep separated it out and left it in the feeder.

Richardson et al. (1966) using six Hereford steers and six Suffolk wether lambs tested the acceptability of DAP, MAP, a blend of MAP-urea and a blend of MAP-DAP. The steers were fed daily 4.54 kg rolled sorghum grain, prairie hay ad libitum which amounted to 3.3 - 5 kg and 0.91 kg of the respective supplement per head. The test products were fed at the start of the test at the 10 per cent level of the supplement, supplying 91 g per head daily. The level was then increased from 10 to 15 per cent (204 g per head daily). The lambs were fed daily 0.68 kg ground sorghum grain, prairie hay ad libitum and 0.141 kg of the respective supplements per head. The lambs were first fed at the 10 per cent level of supplement as were the steers (13.6 g per head daily of the test product. This level was increased to 15 percent as for the steers (34 g of the test products per head daily). Supplements and grain were consumed in about 10 minutes by both steers and lambs so the supplements were acceptable at both the 10 and 15 per cent level. No harmful effects or unusual behavior were observed. Higher levels were not used because it did not seem feasible to ever use higher levels under practical feeding conditions.

McClure and Johnson (1966) conducted a palatability trial with wether lambs using coated and modified DAP compounds. This was done by combining uncoated DAP, urea and SBM with lactic acid ester coated DAP (LADAP) and the two modified DAP materials in all possible paired combinations. When compared with each other, the urea and DAP rations were about equally acceptable. However, it was observed that the SBM was more palatable than all other nitrogen sources. Urea appeared to be more palatable than uncoated DAP when compared with modified DAP. Uncoated DAP proved to be about equal to LADAP.

Schaadt et al. (1966) studied the palatability of four rations equally supplemented on a nitrogen basis with SBM, urea, DAP, and DAP plus urea using 12 wether lambs. Four Hereford steers were used in an additional palatability trial. All possible combinations of two supplemented feeds were fed one week to each lamb and steer. Soybean meal was preferred over urea, DAP, and DAP plus urea by the steers and lambs. In all comparisons it was apparent that the DAP was highly unpalatable. The ration containing the mixture of DAP plus urea was preferred over the one containing DAP alone.

Feeding Trials

Thomas et al. (1961) found that DAP gave about the same response as either urea or SBM when used in a cattle finishing supplement. The DAP and urea was combined with SBM or safflower meal. Greater gain and better feed efficiency were observed for the animals fed the supplement containing DAP and safflower. Both urea and DAP were effectively used as nitrogen additions to safflower or SBM. Animals fed urea or DAP with safflower produced more economical gains than those fed urea or DAP with SBM.

Cowman and Thomas (1962) conducted two trials. Trial one involved a wintering and a fattening phase. The products tested in both phases were DAP, MAP, and urea plus deflourinated rock phosphate. Thirty-two individually fed Hereford steers were studied during the 112 day wintering period. Sources of nitrogen in the supplements, average daily gain (ADG) and pounds of feed per 100 lb gain for this phase were: MAP, 1.10, 924; DAP, 1.14, 901; Urea, 0.97, 1035; SBM, 0.98, 1018. Source of phosphorus in the rations had no significant effect on levels of blood phosphorus. The data indicates that MAP and DAP can be used to supply both nitrogen and phosphorus in protein supplements for wintering steer calves.

The steers were fed the same supplements during the 168 day finishing phase. Sources of nitrogen, (ADG) and pounds of feed per 100 lb gain for the 168 day finishing period were: MAP, 2.81, 676; DAP, 2.95, 673; urea, 2.97, 665; SBM, 3.07, 628.

A second trial by Cowman and Thomas (1962) involved the use of Hereford heifers fed in eight lots of four head each. A low phosphorus ration containing 0.12 percent phosphorus was fed for the 140 day wintering period. The phosphorus level was increased 0.06, 0.12, and 0.18 per cent by adding DAP or deflourinated phosphate to the supplement. Average daily gain for the two control groups (0.12% phosphorus) were 0.92 and 0.94 lbs. Average daily gains for heifers fed added phosphorus from DAP at the three levels were 0.99, 1.02, and 0.90 lb, respectively. Heifers fed added phosphorus from deflourinated phosphate at the same three levels gained 1.05, 0.96, and 0.97 lb per head daily respectively.

Rusoff et al. (1962) used 12 small dairy heifers to study the effect of using urea-phosphate (17.2% nitrogen and 19.9% phosphorus) in a grain ration to supply the required level of phosphorus and to replace part (15%) of the protein. Steamed bone meal was used in the control ration and urea-phosphate plus oyster shell flour was used in the experimental ration. Calcium, phosphorus, crude protein, and total digestible nutrient levels were about equal for both rations. They observed that animals fed urea-phosphate gained slightly more (1.95 lb per day) than those fed the control ration (1.84 lb per day). This difference was not significant.

Oltjen et al. (1963) comparing urea, SBM and DAP found that when DAP supplied 14 per cent of the dietary nitrogen there were no significant differences in feed intake, rate of gain, and feed efficiency as compared to urea fed on a nitrogen equivalent basis. They observed with grazing cattle that those which consumed the urea ration lost less weight (P .05) than those receiving urea plus DAP. When prairie hay was the roughage, the differences between the rations were not significant. They reported that nitrogen supplied by DAP was not as available as that supplied by urea or SBM. Data showed that approximately 50 per cent of the ammonia from DAP was lost in the pelleting process and that ammonia could be released by contact with saliva and water.

Brown et al. (1966) conducted two trials to study the value of DAP and urea as potential sources of protein in beef cattle finishing rations. In each of the two trials no significant differences between treatments were observed in carcass grades, average daily gains, and feed efficiency.

Urea was found to be more toxic than DAP. It was also found that DAP had a lower biological value than urea or SBM. Soybean meal was found to be more palatable than urea or DAP. Feeding trials conducted showed no significant difference between urea or DAP when fed in a finishing ration.

EXPERIMENTAL PROCEDURE

Experimental Animals

Fifty Hereford steers with an average weight of 303 kg were divided into five lots of ten head each, on the basis of weight and conformation. The lots were numbered from one to five consecutively. The steers had been used in a wintering test and fed a ration of sorghum silage, soybean meal and limited grain. Originally, the steers were purchased from the Warner's Ranch in Rice County, Kansas.

All cattle were identified individually with a tattoo in the left ear and a tag, for convenience, in the right ear. The steers were weighed individually on two consecutive days prior to the start of the test and the average of the two weights was used as the initial weight. They were weighed individually once every 28 days during the test. At the termination of the test the steers were again weighed individually on two consecutive days and the average of the two days was used as the final weight.

Supplements

Test supplements fed were (1) control, that consisted of natural protein from soybean meal and dehydrated alfalfa; (2) DAP, that contained 112.5% crude protein equivalent (18% nitrogen) plus 21% phosphorus; (3) a special blend of DAP and urea, that contained 162.5% crude protein equivalent (26% nitrogen) plus 13% phosphorus; (4) urea that contained 262% crude protein equivalent (42% nitrogen) (5) a mixture of DAP plus urea.

All supplements contained dehydrated alfalfa and all except number 5 contained soybean meal. The difference between the DAP-urea blend and DAP plus urea in the supplements that contained both was that the special blend of DAP-urea was made by a single operation by the manufacturer in which the chemical reaction between phosphoric acid and ammonia was stopped prior to completion. The DAP plus urea in the supplement without SBM (5) was added separately and mixed together at the mixing plant at KSU. The ingredients used in these supplements and their amount per 100 kg of supplement are found in Table 1. They were used to formulate supplements that contained equal levels of calcium, phosphorus and total protein equivalent (32%). In addition, the supplements supplied 20,000 I.U. Vitamin A, 70 mg chloro-tetracycline and 10 mg diethylstilbestrol per head daily. The non-protein nitrogen products accounted for two-fifths of the total crude protein in the supplements except the mixture of DAP and urea without SBM which accounted for three-fourths of the total crude protein.

Feeding of Steers

The animals were fed twice daily between 6:30 to 8:00 A. M. and 4:00 to 5:00 P.M. One-half of the respective supplement was fed in the morning along with one-half of the grain, the other one-half being fed at night. The prairie hay was fed at 1:00 P.M. Salt was provided free choice and fresh water was supplied by automatic waterers which were cleaned twice a week.

Table 1. Composition of supplements, %.

Lot No.	1	2	3	4	5
Treatment	Control	DAP	DAP-Urea	Urea	DAP + Urea w/o SBM
Ingredients					
SBM	64.0	30.0	30.0	30.0	--
Molasses	3.0	5.0	5.0	5.0	5.0
Dicalcium phosphate	10.0	--	5.0	12.0	--
Calcium carbonate	3.0	10.0	7.0	2.0	11.0
Dehydrated alfalfa	20.0	25.0	25.0	25.0	25.0
DAP	--	12.0	--	--	11.0
DAP-urea blend	--	--	7.6	--	--
Urea	--	--	--	5.2	4.5
Grain	--	18.0	20.4	20.8	43.5

1. Supplement supplied each animal daily 20,000 I.U. vitamin A, 70 mg chloro-tetracycline and 10 mg diethylstilbestrol.

2. Diammonium phosphate = 18% nitrogen (112.5% protein equivalent) and 21% phosphorus.

3. Diammonium phosphate-urea blend = 26% nitrogen (162.5% protein equivalent) and 13% phosphorus.

4. Urea = 42% nitrogen (262% protein equivalent).

The steers were started on a ration of 4.54 kg prairie hay, 1.82 kg rolled sorghum grain and 0.91 kg of their respective supplement per head daily. Grain was gradually increased to full feed and the hay was decreased to 1.4 kg per head daily. A slight tendency towards scouring was observed for a few days after the animals had been on the grain ration for three weeks. This was considered a normal digestive disturbance during adjustment to the high grain ration. For the last 37 days of the test the hay was reduced to 0.91 kg per head daily. The amount of supplement fed remained the same throughout the test. The supplements were fed in a pelleted form prepared by the Flour and Feed Milling Department at Kansas State University. By July 14, 29 days after the start of the test, all steers were on a full feed of rolled sorghum grain.

Chemical Analysis of the Feed

Proximate analyses were run on the sorghum grain, prairie hay, and the supplements (A.O.A.C., 1960). The results of these analyses are shown in Table 2.

Termination of Test

The test ended December 9, 1965, a total of 177 days. The cattle had access to only prairie hay and water for about six hours prior to shipment. They were loaded from the beef experimental unit at approximately 5:30 P.M. and transported to Armour Packing Company in Emporia, Kansas. They had access to water overnight and were weighed at approximately 8:00 A.M. the next morning and then slaughtered. The carcasses were allowed to chill for about 18-20 hours before data were collected. The data were collected by personnel from the Animal Husbandry Department with the cooperation of the personnel at Armour Packing Company and the USDA meat grader.

Table 2. Proximate analyses of feedstuffs.

Ingredient	Dry Matter	Crude Protein	Ether Extract	Crude Fiber	Nitrogen Free Extract	Ash
Prairie hay	92.5	3.9	2.1	29.6	49.1	7.8
Sorghum grain	87.2	11.3	1.9	1.7	71.2	1.2
Supplements:						
Control	89.8	33.7	1.2	7.8	34.4	12.8
DAP	89.9	35.8	1.5	7.9	29.5	15.3
DAP-urea	90.4	35.1	1.5	7.7	33.5	12.7
Urea	89.8	33.5	1.5	7.4	33.6	13.8
DAP + urea w/o SBM	90.0	33.2	1.9	6.9	34.1	14.0

RESULTS AND DISCUSSION

A summary of the results is presented in Table 3. The following paragraphs discuss these results.

Feed Consumption and Feed Efficiency

Table 4 summarizes each 28 day interval feed consumption by lots. Figure 1 shows a comparison of feed consumption in the different weigh periods. Table 5 gives the total feed per kilogram of gain for each weigh period and Fig. 2 is a graphical presentation of the feed efficiency for each weigh period. Feed consumption and feed efficiency were similar between lots. However, it was observed that lot 2 ate the most feed of all lots and had the poorest feed effieiency (8.94 kg feed/kg gain).

Table 3. Summary results finishing steers with different protein supplements (June 15-December 9, 1965, 177 days).

Lot No.	1	2	3	4	5
Treatment	Control	DAP	DAP-urea	Urea	DAP + Urea w/o SBM
No. steers per lot	10	10	10	10	10
Av. initial wt., kg	302.7	303.4	303.6	303.0	302.7
Av. final wt., kg	508.0	518.2	516.4	517.7	506.8
Av. daily gain, kg	1.16	1.21	1.20	1.21	1.16
Av. daily ration, kg					
Sorghum grain	7.59	8.27	7.91	7.82	7.50
Prairie hay	1.68	1.68	1.68	1.68	1.68
Supplement	.91	.91	.91	.91	.91
Feed per 100 kg gain					
Sorghum grain	655	683	658	646	650
Prairie hay	143	137	138	137	144
Supplement	77	74	75	74	78
Feed cost per kg gain[1]	$40.83	$39.89	$40.22	$39.05	$39.16
Shrink to market,%	1.97	2.68	2.33	2.28	3.32
Av. hot carcass wt., kg	307.9	309.6	313.9	311.1	300.7
Av. dressing %, feed lot wt.	60.6	59.7	60.8	60.1	59.3
Av. fat thickness 12th rib, cm	2.18	2.26	2.05	1.83	1.93
Av. size rib-eye, sq. cm.	73.87	75.11	74.83	78.26	75.36
Av. degree marbling[2]	5.0	5.4	5.0	5.0	5.2
Estimated kidney knob, %	2.55	2.75	2.55	2.50	2.35
Carcass grades					
Top choice	--	--	--	--	1
Medium choice	1	4	2	2	3
Low choice	8	6	6	6	4
Top good	1	--	2	2	2
Av. carcass grades[3]	19	19.4	19	19	19.3

[1]Prairie hay 2.2¢ per kg, sorghum grain 4.4¢ per kg; Lot 1 supplement 11.04¢ per kg; Lot 2 supplement 9.42¢ per kg; Lot 3 supplement 11.02¢ per kg; Lot 4 supplement 10.31¢ per kg; Lot 5 supplement 9.48¢ per kg.

[2]4 = slight, 5 = small, 6 = modest.

[3]21 - high choice, 20 = medium choice, 19 = low choice, 18 = high good, 17 = medium good, 16 = low good.

Table 4. Twenty-eight day average feed consumption (kg) by treatment.

Lot No.	1	2	3	4	5
Treatments	Control	DAP	DAP-urea	Urea	DAP + Urea w/o SBM
No. steers per lot	10	10	10	10	10
Period					
6/15- 7/13	2963.6	2963.6	2963.6	2963.6	2963.6
7/13- 8/10	2790.9	2863.6	2879.6	2809.1	2802.3
8/10- 9/7	2845.5	3202.3	2986.4	2981.8	2881.8
9/7 -10/5	2990.9	3206.8	2972.7	2929.6	2900.0
10/5 -11/2	3006.8	3256.8	3097.7	3097.8	3002.3
11/2 -11/30	2477.3	2752.3	2706.8	2675.0	2311.4
11/30-12/9	901.6	949.3	913.0	935.7	933.4
Total	17976.6	19194.8	18519.8	18392.5	17794.8

Table 5. Feed efficiency (kg feed/kg gain).

Lot No.	1	2	3	4	5
Treatment	Control	DAP	DAP-urea	Urea	DAP + Urea w/o SBM
Periods					
6/15- 7/13	8.31	9.12	9.18	9.95	8.87
7/13- 8/10	8.71	9.20	7.97	8.77	10.28
8/10- 9/7	9.27	7.96	9.59	8.52	7.59
9/7 -10/5	10.20	9.80	7.56	7.91	9.31
10/5-11/2	9.80	11.84	13.91	12.17	15.92
11/2-11/30	6.49	8.84	7.18	7.40	7.16
11/30-12/9	10.44	4.86	6.59	4.84	4.03
Average	8.76	8.94	8.71	8.56	8.72

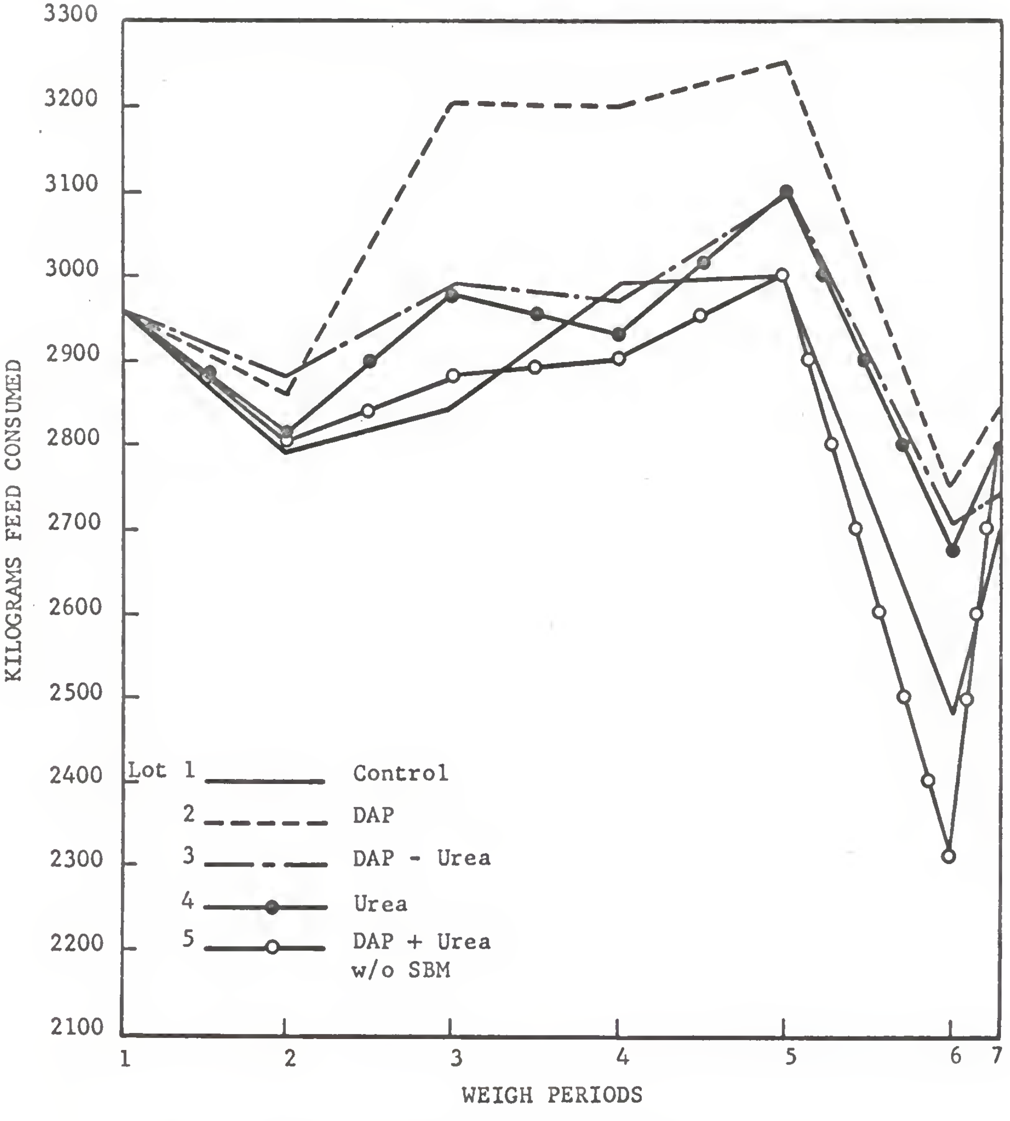

Fig. 1. Feed consumption by 28 day weigh periods.

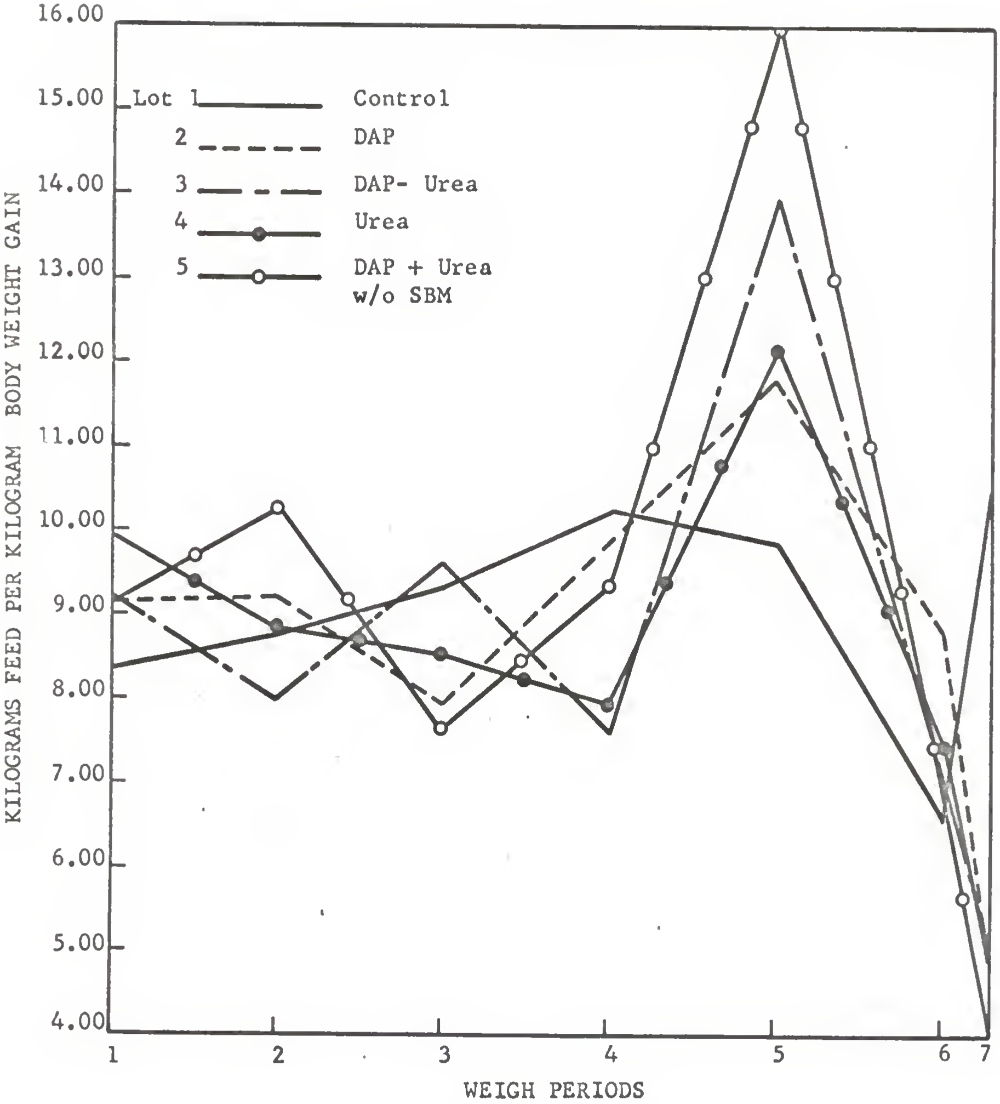

Fig. 2. Efficiency of feed utilization by 28 day weigh periods.

Lot 5 ate the least feed of all. This was apparently caused by the supplement being unpalatable. Lassiter et al. (1962) also found that dairy cows offered some resistance to grain consumption when DAP was fed at two per cent level of the total ration until they became accustomed to it. The supplement that contained urea seemed to be the most palatable. The steers that received urea would eat the supplement if it was left setting in a container by itself. This lot had the best efficiency (8.56 kg feed/kg gain). Johnson and McClure (1963) found that urea was utilized better than DAP when fed to sheep. They fed corn cobs, soybean flakes, starch, ground shelled corn, minerals and vitamins A and D supplemented with urea, biuret or DAP.

Oltjen et al. (1963) reported that the ration containing DAP was not digested as well as the ration supplemented with SBM or urea. They stated that the nitrogen supplied by DAP was not as available as that supplied by urea or SBM.

Brown et al. (1966) found no significant difference in feed efficiency between steers fed DAP or urea. Lassiter et al. (1962) reported no difference in nitrogen digestion in rations containing DAP, urea or SBM.

Feed consumption for all lots, especially lot 5, increased sharply the last weigh period. The lot 5 increase may be accounted for since 0.91 kg of SBM replaced the unpalatable DAP + urea mixture. It was noted that as soon as SBM was fed, grain consumption increased rapidly.

Table 6 shows the feed efficiency of grain utilization (kg of feed/kg gain by weigh periods). The efficiency of grain utilization parallels that of total feed efficiency.

Table 6. Efficiency of grain utilization (kg grain/kg gain)

Lot No.	1	2	3	4	5
Treatment	Control	DAP	DAP-urea	Urea	DAP + Urea w/o SBM
Periods					
6/15- 7/13	4.57	5.02	5.06	5.48	5.37
7/13- 8/10	6.71	7.14	6.20	6.77	7.93
8/10- 9/7	7.20	6.38	7.55	6.70	5.92
9/7 -10/5	8.03	7.85	5.94	6.19	7.27
10/5 -11/2	7.73	9.53	11.05	9.67	12.54
11/2 -11/30	5.16	7.20	5.83	5.99	5.59
11/30-12/9	8.84	4.15	5.59	4.13	3.43
Average	6.55	6.83	6.58	6.46	6.50

Average Daily Gains

Average daily gain for each lot by 28 day weigh periods is summarized in Table 7 and presented graphically in Fig. 3. Average daily gain (ADG) was highest (1.21 kg) for lots 2 and 4. The lowest ADG (1.16 kg) was observed for lot 1 (control) and lot 5. These lots also consumed the least feed. There were no significant differences in ADG between lots.

Thomas et al. (1961) also reported that urea and DAP gave about the same results when used in a cattle finishing supplement. Lassiter et al. (1962) found that the rates of gain for dairy heifers fed urea, DAP, or urea plus DAP were essentially the same. Brown et al. (1966) found no significant difference in ADG of Hereford steers fed urea or DAP.

Table 7. Summary of average daily gains (kg) for each weigh period by treatment.

Lot No. Treatment Periods	1 Control	2 DAP	3 DAP-urea	4 Urea	5 DAP + Urea w/o SBM
6/15- 7/13	1.27	1.16	1.16	1.06	1.20
7/13- 8/10	1.15	1.11	1.29	1.15	.97
8/10- 9/7	1.10	1.44	1.11	1.25	1.36
9/7 -10/5	1.05	1.17	1.40	1.32	1.11
10/5 -11/2	1.10	.98	.80	.91	.67
11/2 -11/30	1.36	1.11	1.35	1.29	1.16
11/30-12/9	.96	2.17	1.54	2.15	2.58
Average	1.16	1.21	1.20	1.21	1.16

From Fig. 3 it can be seen that lots 2, 4, and 5 made outstanding gains for the last weigh period. Lot 3 had a higher ADG for the last period than the ADG for the whole test of all lots up to the last weigh period. The last weigh period consisted of 9 days and lot 1 was the only one that showed a decrease in gain. The sharp increases and decreases in the rate of gain by weigh periods are difficult to explain. Weather and fill, along with other unknown factors, were the probable causes.

Table 8 is a summary of the average weights of the animals in their respective lots for each weigh period. Figure 4 shows a graphical comparison of the monthly weights which remained relatively similar

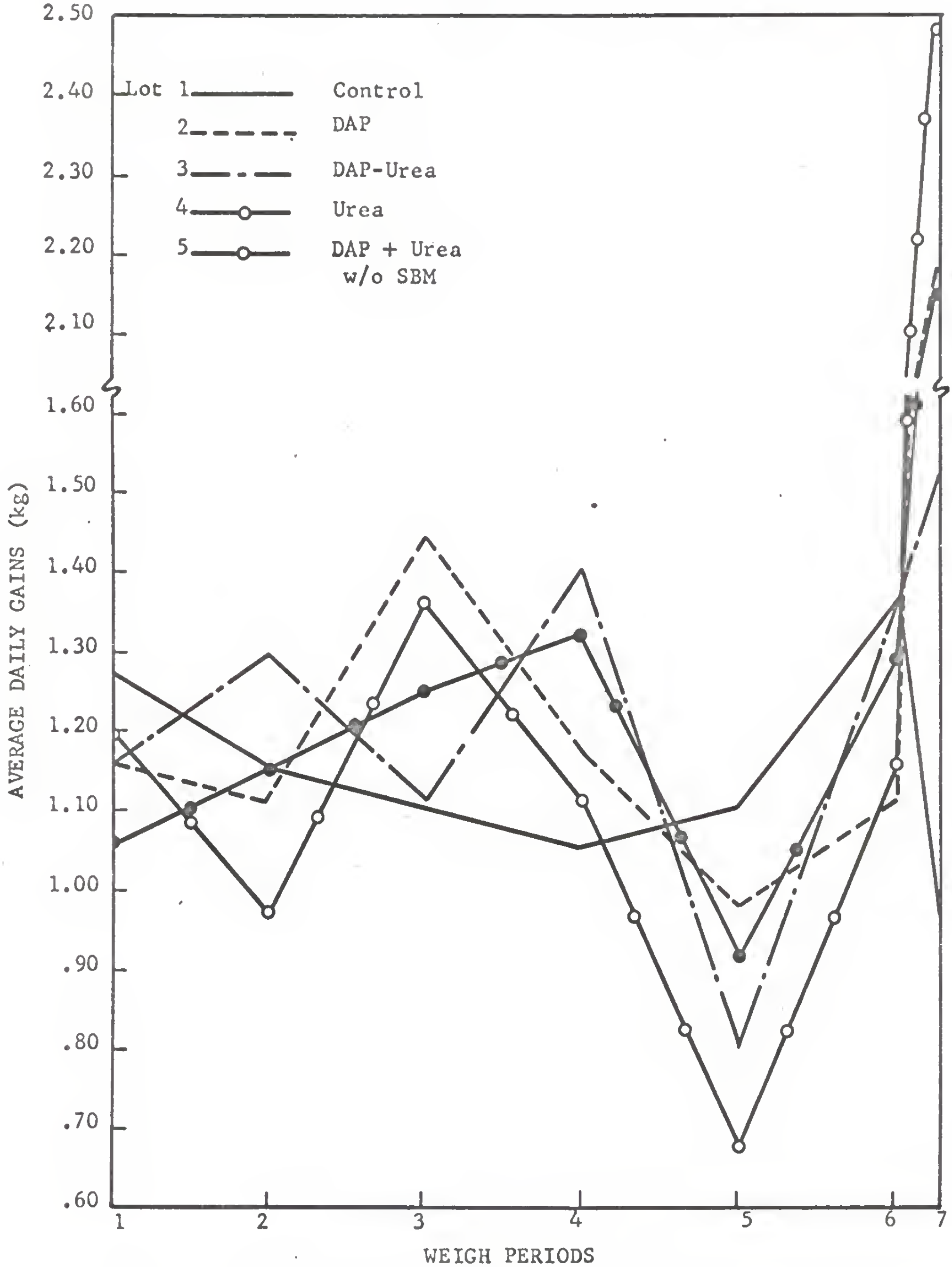

Fig. 3. Trends in average daily gains by 28 day weigh periods.

Table 8. Summary of average weights (kg) of the steers for each weigh period by treatment.

Lot No. Treatments Periods	1 Control	2 DAP	3 DAP-urea	4 Urea	5 DAP + Urea w/o SBM
6/15- /65	302.7	303.4	303.6	303.0	302.7
6/15- 7/13	338.4	335.9	335.9	332.7	336.1
7/13- 8/10	370.5	367.1	372.1	364.8	363.4
8/10- 9/7	401.1	407.3	403.2	399.8	401.4
9/7 -10/5	430.5	440.0	442.5	436.8	432.5
10/5-11/2	461.1	467.5	464.8	462.3	451.4
11/2-11/30	499.3	498.6	502.5	498.4	483.6
11/30-12/9	508.0	518.2	516.4	517.7	506.8

throughout the test. It was noted however, that cattle in lot 2 were the heaviest and that cattle in lot 5 were the lightest at the termination of the test. There was a difference of 11.4 kg in the average weights between lots 2 and 5. The differences in the average weights for lots were not significant. Cattle in lot 2 also consumed the most feed and those in lot 5 the least.

Carcass Characteristics

Individual and average dressing percentages by treatment calculated from the warm carcass weight divided by the feedlot weight, are summarized in Table 9. There were no significant differences between the means of

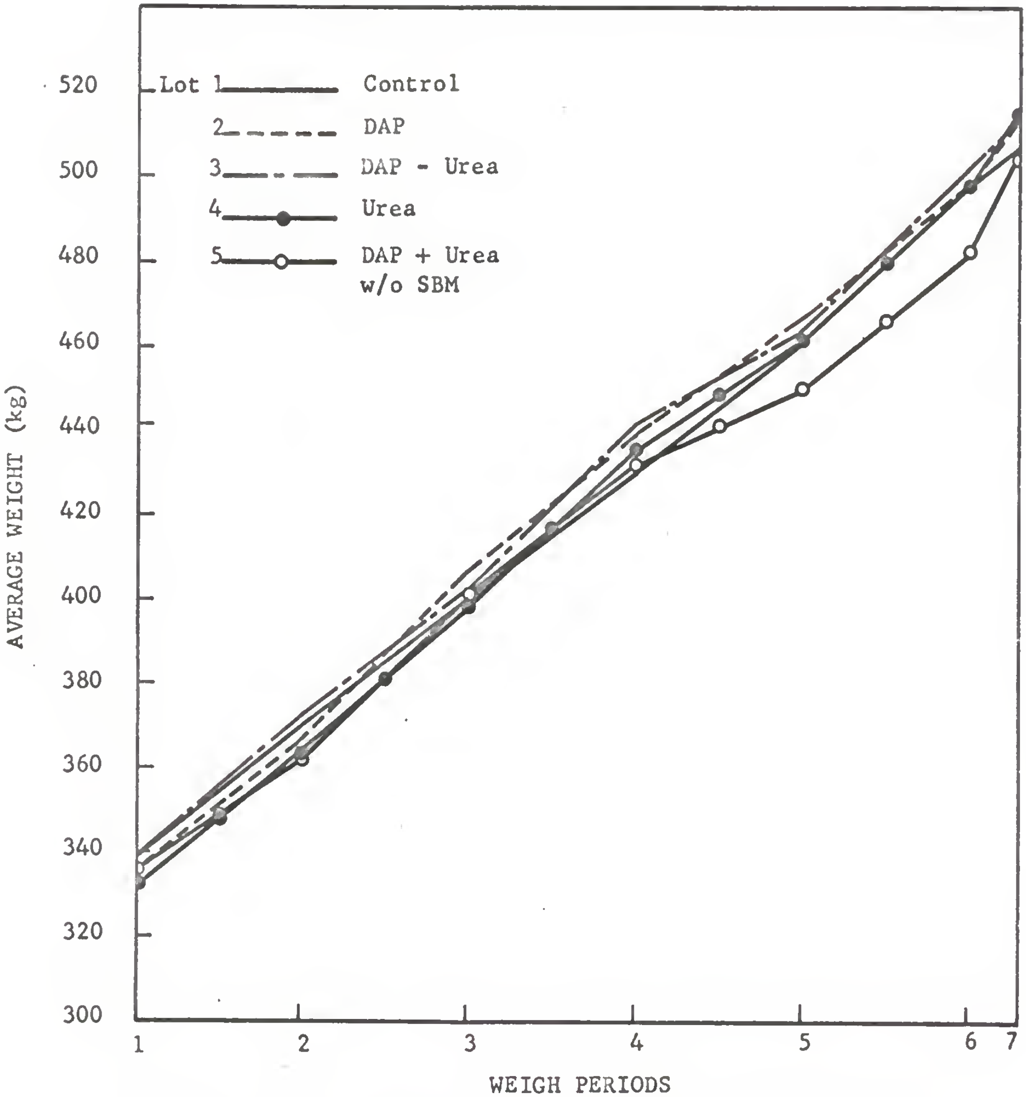

Fig. 4. Growth curves by 28 day periods from June 15 to December 9, 1965.

Table 9. Carcass dressing percentage.[a]

Lot No. Treatments	1 Control	2 DAP	3 DAP-urea	4 Urea	5 DAP + Urea w/o SBM
	61.23	61.55	59.90	59.43	59.41
	62.55	61.28	62.68	61.10	61.15
	60.44	52.45	61.37	59.12	60.28
	58.80	60.88	60.18	59.92	58.85
	59.39	59.82	61.13	62.82	58.33
	61.66	60.50	60.67	61.89	58.81
	61.00	59.38	60.95	59.81	59.28
	59.44	61.63	61.88	59.28	59.37
	61.38	59.91	58.10	59.14	58.69
	60.09	61.06	60.88	58.78	59.13
Average	60.64	59.74	60.79	60.10	59.34

[a]Dressing percent = warm carcass weight divided by feed lot weight and expressed as percent.

the five groups of cattle. The lot with the highest average dressing percentage of 60.79% was the one that received the special blend of DAP plus urea (lot 3). The lowest dressing percentage (59.34%) was lot 5, which received the supplement that contained a mixture of DAP plus urea without SBM. Feed consumption was lowest for this lot and this probably accounted for the cattle showing less finish and having a lower dressing percentage. Although feed consumption for lot 5 increased when the supplement was replaced by SBM for the last few days of the test, the time did not last long enough for the finish of these cattle to equal that of the other lots.

Table 10 gives the individual and average rib-eye area by treatments. There were no significant differences observed between the means of the treatments.

Table 11 summarizes the individual and average backfat thickness by treatments. There were no significant differences between the treatments.

Carcass grade of an animal is largely determined by age, marbling, conformation, rib-eye area, and backfat thickness. Table 12 is a summary of the carcass grades obtained at the slaughter house. The average grade of all five lots was low choice with lots 1, 3, and 4 being exactly the same when graded numerically. Lot 2 had the highest average numerical grade of 19.4. It was somewhat surprising that lot 5 graded next to lot 2 with a grade of 19.3. These steers showed less finish than those in other lots.

Brown et al. (1966) found no significant differences between carcass data obtained from Hereford steers fed DAP, urea, or cottonseed meal (CSM). This is in agreement with results of this test.

Table 10. Rib-eye area at the 12th rib, sq. cm.[1]

Lot No. Treatments	1 Control	2 DAP	3 DAP-urea	4 Urea	5 DAP + Urea w/o SBM
	75.36	82.62	63.88	72.72	82.32
	76.58	72.06	94.39	88.65	81.94
	71.76	84.33	66.14	72.26	85.22
	62.00	71.55	69.93	77.04	62.46
	76.84	77.55	76.58	81.23	82.19
	73.56	77.67	87.30	75.90	75.90
	72.72	67.16	77.93	82.83	70.64
	65.23	74.83	73.28	75.62	71.93
	78.59	77.80	70.38	70.51	76.91
	86.18	65.48	68.38	86.13	64.01
Average	73.86	75.11	74.83	78.26	75.36

[1]Measured with planimeter and converted to sq. cms.

Table 11. Back-fat thickness at 12th rib cm.

Lot No. Treatments	1 Control	2 DAP	3 DAP-urea	4 Urea	5 DAP + Urea w/o SBM
	2.29	1.78	1.78	1.78	1.32
	2.29	2.74	2.29	1.83	1.78
	3.51	2.29	2.54	1.45	1.78
	1.98	2.92	1.78	3.05	2.29
	.97	2.26	2.16	1.78	2.06
	2.03	2.54	1.58	1.27	1.40
	2.54	2.54	3.30	1.73	1.40
	1.85	2.21	1.27	2.16	1.40
	1.83	1.55	1.27	1.91	3.05
	2.54	1.80	2.67	1.45	2.79
Average	2.18	2.26	2.06	1.83	1.93

Table 12. Carcass grades by treatment.

Lot No. Treatments	1 Control	2 DAP	3 DAP-urea	4 Urea	5 DAP + Urea w/o SBM
	19	19	19	20	19
	19	20	18	19	18
	18	20	20	19	19
	19	20	18	18	20
	19	19	19	20	21
	19	19	19	19	20
	19	20	20	18	20
	19	19	19	19	18
	19	19	19	19	19
	20	19	19	19	19
Average	19	19.4	19	19	19.3

21 = high choice

20 = medium choice

19 = low choice

18 = high good

17 = medium good

16 = low good

SUMMARY

Fifty Hereford steers were divided equally into five lots to study the value of different non-protein-nitrogen (NPN) sources, diammonium-phosphate (DAP) and urea in the ration for finishing beef cattle. The five treatments were (1) control, (2) DAP, (3) special blend of DAP and urea, (4) urea, and (5) DAP plus urea without SBM. All supplements contained dehydrated alfalfa and soybean meal (SBM) except the latter which did not contain SBM.

Poor palatability was observed with the supplement that contained DAP plus urea without SBM. As the test proceeded, the cattle began to accept it better.

The results of this test showed that the cattle that received DAP were the heaviest and those fed DAP plus urea without SBM were the lightest at the termination of the test, but this was not significantly different. The highest average daily gain was 1.21 kg per head for the two lots fed DAP, and urea, respectively. The average daily gains for the five lots were not significantly different.

Grain consumption was not greatly different. Those fed DAP consumed more feed than the others, and those fed DAP plus urea without SBM, the least.

The cattle that received the urea had the best overall feed efficiency and those that received DAP, the poorest. The steers that received the special blend of DAP plus urea had a slightly higher average dressing percentage than the steers of the other treatments. Steers that received

DAP plus urea without SBM had only a slightly lower dressing percentage than the other steers. Area of rib-eye muscle was not significantly different. Area of rib-eye muscle was larger for those fed urea and least for those fed the control ration. Back-fat was thickest from the cattle fed DAP and the smallest amount was present on those fed urea, but this was not significantly different. Overall carcass grades were essentially the same, with the steers that received the DAP grading only slightly higher than the others. Those that received urea made the cheapest weight gain.

Since DAP can be priced competitively with urea and phosphorus as a feed ingredient, it can be used effectively in supplements for beef cattle finishing rations.

ACKNOWLEDGMENT

I wish to take this opportunity to thank Dr. D. Richardson who carefully planned and supervised my studies during my graduate program at Kansas State University. I am also grateful to him for his unselfish co-operation and well-considered criticisms during all the critical stages of this experiment.

To the Head of Department, Dr. D. L. Good, members of the staff, and secretaries, I wish to express my appreciation for the spirit of friendship and willingness with which they all availed themselves of their services and facilities at all times.

My sincere thanks also goes to Dr. Y. O. Koh of the Statistics Department for helping with the statistical analyses.

I wish to dedicate this work to my wife and to my parents who have given me the encouragement for the success of my academic career.

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SOURCES OF NON-PROTEIN NITROGEN IN STEER FINISHING RATIONS

by

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B. S., Kansas State University, 1965

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

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KANSAS STATE UNIVERSITY
Manhattan, Kansas

1967

Fifty Hereford steers averaging 303 kgs were divided into five lots of ten head each on the basis of weight and conformation, to study the value of diammonium-phosphate and urea in the finishing ration of beef cattle. The five treatments were (1) control, (2) DAP, (3) special blend of DAP and urea, (4) urea, and (5) DAP plus urea without SBM. All supplements contained dehydrated alfalfa and SBM except the latter which did not contain SBM.

The supplement that contained DAP plus urea without SBM seemed to be unpalatable at first, but the cattle began to accept it better as the test progressed.

There were no significant differences in average daily gains, however, the cattle that received DAP were the heaviest (518.2 kg) and those fed DAP plus urea without SBM were the lightest (506.8 kg) at the termination of the test. The highest average daily gain was 1.21 kg per head for the two lots that received DAP and urea, respectively. The lowest average daily gain was 1.16 kg per head for the lots fed the control ration and DAP plus urea without SBM.

Grain consumption was not greatly different. Those fed DAP consumed more feed than the others, and those fed DAP plus urea without SBM, the least.

The best feed efficiency (8.56 kg/kg gain) was that of the cattle that received urea and the poorest feed efficiency (8.94 kg/kg gain) was for those that received DAP.

Carcass characteristics were not significantly different. The steers fed the special blend of DAP plus urea had the highest dressing percentage

(60.79). The lowest dressing percentage was the lot that received DAP plus urea without SBM (59.34). Area of rib-eye muscle was greatest (78.26 sq. cm.) for those fed urea and least (73.86 sq. cm.) for those fed the control ration. Back-fat thickness was not significantly different. Back-fat was thickest (2.26 cm.) from the cattle fed DAP and the smallest amount (1.83 cm.) was present on those fed urea. Overall carcass grades were essentially the same. Feed cost per 100 kg liveweight gain was lowest for the steers fed urea ($39.05/100 kg) and highest for the ones fed the control ration ($40.83/100 kg).

The results indicate the sources of protein used to be of equal value in the finishing ration of beef steers.