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COMPARISON OF SOYBEAN MEAL, STAREA
AND UREA IN FEEDLOT SUPPLEMENTS

by

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INTRODUCTION

Beef production is perhaps the most dynamic section of the agricultural economy in the more developed countries. This arises from an increasing consumer demand for red meat as a result of growing population and purchasing power. Warwick (1971) estimated that, for example, about 95 percent of the beef and veal consumed in the United States is home produced. In the United Kingdom, Australia and New Zealand livestock accounts for about 72 percent and 92 percent of the total agricultural activities (Oyenuga, 1966). This is often the reason for the production of cereal grains and extensive grassland farming in these countries.

In the developing countries of Asia, Latin America and Africa livestock are also important, and many of these countries have large livestock population, especially cattle. Too often, however, the conditions under which the livestock are maintained militate against efficient output per animal. In many of these countries cattle are still used for work and draft, but as mechanization takes place it is hoped that more of the cattle can be put to producing greater yields of meat. The world beef shortage appears to further emphasize that the developing countries must use their cattle population to the best advantage.

In view of the strong competition between beef and other meats, and owing to rising cost of production in the cattle industry, cattle feeders must constantly seek new ways of reducing feed costs. Small differences in rate of gain and feed efficiency may mean the difference between profit and loss. One of the ways of reducing this cost has been the use of non-protein-nitrogen compounds, especially urea, as protein supplements in ruminant diets. The use of urea and such other compounds has taken an accelerated pace in recent

years, because a backlog of research data has shown that these compounds can at least replace part of and are cheaper than the conventional protein sources in ruminant diets. Full utilization of urea by ruminants has, however, been limited by several factors. But recently Bartley et al. (1968) reported a starch-controlled urea product (Starea) which proved in all respects to be better utilized than urea and is about equal to soybean meal as protein supplement. Further experiments by several workers have since then documented their findings.

Growth and finishing studies were conducted with steers to compare five supplements--soybean meal, soybean meal with urea (50:50), urea, Milo Starea-70 (70 percent protein equivalent) and Wheat Starea-70--in a basal ration of corn silage and rolled milo. Later on, digestion and rumen metabolic studies were conducted to further evaluate the supplements on the basis of nitrogen balance.

This research work was motivated by the possibility of providing additional information on the utilization of Starea in extending protein supplies in practical feedlot situations.

PART I

REVIEW OF LITERATURE

Nitrogen Utilization by Ruminants

Ruminant diet consists primarily of roughage and most of the nitrogen in this diet is therefore in the form of plant protein. However, the proteolytic properties of the rumen contents was not readily understood until the work of Pearson and Smith (1943) which showed for the first time that both synthesis and breakdown of protein occurred in the rumen. In their experiments on the mechanism of non-protein nitrogen utilization by ruminants, Johnson et al. (1944) agreed with the general hypothesis that, in ruminants, much of the food nitrogen, whether of protein or of non-protein source, was first synthesized by the rumen microorganisms into their own cellular proteins before the host animal finally digested them. McDonald (1948, 1952, 1954) and McDonald and Hall (1957) further reported that about 90 percent of a soluble protein, such as casein, in the diet was fermented to ammonia in the rumen. In his in vitro studies, Hungate (1966) showed that the rate of digestion of proteins by rumen bacteria, in fact, varied widely and was correlated with the solubility of the protein in salt solutions, thus lending further support to the work of McDonald and others. It soon became obvious that the ruminant could obtain its essential amino acids from the digestion of microbial protein synthesized in the rumen as well as from the digestion of dietary protein which escaped rumen fermentation (Ferguson, 1972).

The extensive degradation to ammonia of ingested proteins by rumen microbial population before passing on to the abomasum and small intestine as microbial protein for digestion is in sharp contrast to the direct enzymatic

digestion of the ingested preformed proteins in monogastrics (Johnson et al., 1944; Reid, 1953; Annison and Lewis, 1959; Hungate, 1966; Lampila, 1972; Church, 1972). It has been amply demonstrated (Blackburn and Hobson, 1960; Little, Burroughs and Woods, 1963; Borchers, 1965, Freitag et al., 1970) that the relative contribution of such microbial and feed proteins to the ruminant's nitrogen utilization is very much dependent upon the feed protein source.

Non-Protein-Nitrogen Sources in Ruminant Rations

Evidence was obtained by Zuntz as far back as 1891 that ruminants were capable of utilizing non-protein-nitrogen (Church, 1972). Since then numerous workers have examined non-protein-nitrogen sources as partial or total substitute in ruminant rations partly from the point of view of economics and partly from the standpoint of the value of these compounds for growth, meat, lactation and wool production. Paasch (1925) found ammonium acetate to be a successful protein substitute in rations for goats. Ehrenberg et al. (1932, 1933), Windheuser et al. (1936), Kirsch and Jantzan (1934) and Hart et al. (1939) reported that ammonium bicarbonate could replace part of the protein in rations for dairy cattle. But perhaps one of the most outstanding investigations in this area at this time was the work of Loosli et al. (1949) in which it was found that all ten essential amino acids were synthesized in the rumen of sheep when urea furnished all the nitrogen of the ration. Repp et al. (1955) compared the feeding value of ammonium propionate, ammonium formate, formamide and propionamide, in addition to urea and ammonium acetate, with protein from natural feed sources in feeding experiments with lambs. These compounds replaced as much as 50 percent of the protein nitrogen of the ration. These workers reported that while formamide was found to be inferior

to other compounds examined, the remaining non-protein-nitrogen compounds appeared to be of about equal value in supporting growth as measured by weight gains of lambs. One of their experiments however, indicated that the non-protein-nitrogen compounds did not support as high rates of gain as did the preformed proteins at the 50 percent replacement level. At 15 percent and 30 percent replacement levels in another experiment it was found that weight gains with propionamide and urea were similar to those of conventional proteins.

Urea constitutes a feed source of nitrogen potentially capable of substantially extending feed supplies of conventional proteins in ruminant rations. It is becoming increasingly important to the feeding industry as a protein substitute, and great amount of interest has been shown in the results of both feedlot and range tests with urea feeds. Early experiments in Germany as well as feeding trials with sheep and cattle (Bartlett and Cotton, 1938; Hart et al., 1939; Rupel et al., 1943; Archibald, 1943; Loosli and McCay, 1943; Owen, 1943; Willet et al., 1946; Briggs et al., 1947, 1948; Gallup et al., 1953; Repp et al., 1955a; Williams et al., 1969) all demonstrated the value of urea as a partial protein substitute in ruminant rations. Harris and Mitchell (1941), Johnson et al. (1942), Harris et al. (1943), Briggs et al. (1946) gave further information through nitrogen balance experiments that limited amount of urea could be converted into useful protein. The method of conversion was earlier on shown to be through the growth of rumen micro-organisms (Voltz, 1919; Wegner et al., 1940). This was later confirmed by other workers (Pearson and Smith, 1944; Lampila, 1967).

Full utilization of urea has been limited by the fact that it usually undergoes such rapid hydrolysis that much of the ammonia is absorbed from the rumen before the microorganisms can incorporate it into their own body protein

Since, apart from palatability and segregation in mixed rations, the other major limiting factor is this increase of ammonia in the rumen which can lead to toxicity, the advantageous use of urea is limited to conditions where ammonia concentration would be below optimal for the rumen microorganisms. Many workers (Arias et al., 1951; Reid, 1953; Annison and Lewis, 1959; Raleigh and Wallace, 1963; Karr et al., 1965; Hungate, 1966; Lampila, 1967; Haskins et al., 1967; Chalupa, 1968) have suggested that the improved utilization of urea nitrogen could be achieved by attempting to (1) reduce the rate of urea hydrolysis in the rumen or to convert urea to a less soluble form, (2) increase the capability of rumen microorganisms to utilize the available ammonia nitrogen, (3) increase tissue utilization of ammonia, nitrogen, and (4) increase the quantity of urea nitrogen recycled to the rumen. An extensive review in the utilization of urea as a partial protein substitute in ruminant diets has been made by Reid (1953).

Evaluating the mechanism of non-protein-nitrogen utilization by ruminants, Johnson et al. (1944) suggested that feed proteins which undergo conversion to microbial protein in the rumen have similar biological values, while proteins not used by these microorganisms differ in biological values as when fed to simple gutted animals. In their nitrogen balance work with sheep, Lofgreen et al. (1947) obtained results which indicated that the quality of protein as fed in the rations of lambs might be of importance under certain conditions. They therefore considered it logical to assume that if protein quality had an effect upon the nitrogen retention of lambs, then it might also have similar effect upon gains in weight in feedlot operations. Karr et al. (1965) reported no significant effect on rate of gain between urea and biuret in ensiled finishing lamb rations. However, Richardson et al. (1966, 1967, 1968) found that urea was less efficient than soybean meal without added

grain in a wintering ration for steer calves. In general the value of nitrogen source for the ruminant depends primarily on its capacity to supply nitrogen that can be utilized by rumen microorganisms, its acceptability to the animal and its toxicity.

Urea and Carbohydrates Vs. Vegetable Proteins

Results from several experiments have indicated that protein and carbohydrate digestion in the rumen show considerable interdependence. This has led to a general conclusion that protein is more readily utilized in the presence of added carbohydrate, and that the more fibrous components of the feed are more rapidly attacked with increasing protein intake.

Ruminant rations containing largely urea nitrogen and carbohydrates have, however, been observed to consistently produce slower growth and gains than rations supplying equivalent amounts of protein nitrogen and energy from plant sources. A need for available carbohydrate soon after ingestion of urea was indicated by the work of Lenkeit and Becker (1938), Wegner et al. (1941) and Pearson and Smith (1943) who demonstrated that urea is rapidly hydrolyzed. They found that this need appeared to be met by starch. In the growth experiments with dairy heifers Mills et al. (1942) tested the influence of starch on urea utilization. It was shown that the addition of urea to timothy hay and starch increased the protein content of the rumen from 6.8 to 10.7 percent. It was also observed that the amount of ammonia nitrogen disappearing from the rumen contents in six hours was approximately equivalent to the nitrogen contained in the additional protein formed. This indicated that most of the urea nitrogen was built into protein.

The source of energy furnished the rumen microorganisms is known to exert varying influences upon urea utilization. This fact was supported by

Johnson et al. (1942) in their nitrogen balance experiments with lambs. Mills et al. (1944) reported that starch was superior to molasses in vivo in promoting protein synthesis from a ration containing urea. Arias et al. (1951) however reported that when dextrose, cane molasses, sucrose, starch, cellulose and ground corn cobs were used, each source of energy, whether a readily available carbohydrate or a complex carbohydrate, such as cellulose, aided urea utilization provided the latter was digested. Pope et al. (1951) also found that the improvement in the retention of nitrogen by steers was the same when urea supplemented rations contained 50 percent prairie hay and 50 percent of either corn or molasses, or 25 percent of corn and 25 percent of molasses. Belasco (1956) further examined the role of various carbohydrates on urea utilization. He found that urea utilization by rumen microorganisms in vitro was dependent on the amount and type of carbohydrate used as the energy source. He also reported that the extent of urea utilization was slightly greater with starch than with cellulose and that although xylan and pectin promoted urea utilization, it was to a lesser extent than starch. These results appear to be in agreement with the earlier findings of Mills and co-workers. Using readily fermentable carbohydrates and all-urea supplemented rations for lambs, McLaren et al. (1965) reported that the utilization of non-protein-nitrogen in semi-purified diets was related to both its energy level and the duration of time the lambs were fed the diet. Richardson et al. (1966, 1967, 1968) observed that beef steers fed a wintering ration containing urea plus three pounds of grain performed as well as steers supplemented with soybean meal. Similar results were reported by Smith et al. (1968) comparing one percent urea and soybean meal in all concentrate cattle finishing rations. These workers found that steers fed urea supplement required slightly less feed per pound of gain, 5.9 to 1 as against 6.5 to 1 for soybean meal.

Greathouse et al. (1969) carried out some work whose results, in general, were in agreement with the above. Results of one experiment however, indicated that steers fed soybean meal required least feed per pound of gain, but there was little or no difference by treatment in neither the carcasses nor feed cost per hundred weight of gain.

Improving Urea Utilization by Ruminants

The work of Bartley et al. (1968) in the development of Starea, a processed intimate mixture of gelatinized starch and urea, was designed to overcome problems associated with urea including inefficient conversion of nitrogen to protein, toxicity, lowered palatability and segregation in mixed rations. Starea is produced by passing mixtures of finely ground grains or other starch sources and urea through a cooker-extruder to cause starch gelatinization.

The approach was to use more readily available carbohydrate sources, whose breakdown in the rumen would be similar to that of urea, so as to provide the rumen microorganisms simultaneously with the carbon skeleton for microbial protein synthesis. In the feeding experiments which followed, these workers showed that starch enhanced ammonia utilization more than cellulose or glucose. They found cooked starch to be more satisfactory than raw starch. Through several trials, Starea containing rations have since then been associated with improved palatability, lowered rumen ammonia concentrations, less toxicity problems, increased microbial protein synthesis, and increased weight gains and milk production (Bartley et al., 1968; Helmer et al., 1970a, 1970b; Stiles et al., 1970).

Bartley et al. (1968) conducted milk production studies with Starea. They reported that cows on grain rations with added soybean meal or Starea

consumed more grain and produced more milk, containing a higher percentage protein, than cows fed the same grain ration supplemented with urea. The urea fed cows also lost weight. The grain intake, milk production and body weight of the Starea and soybean meal rations were found to be similar. In one experiment the value of 44 percent soybean meal and Starea 34 (34 percent protein equivalent) as nitrogen supplements for lactating cows was compared. Both rations contained 14 percent protein equivalent. These same researchers found that both supplements were equal as protein sources for lactating dairy cows. When 44 percent soybean meal and Starea 44, both containing 16 percent protein equivalent, were used in another trial, their results still indicated that there were no significant differences in the performance of cows fed the two supplements. Their results therefore led to a general conclusion that when Starea contained 24, 34 or 44 percent protein equivalent, it was equal to soybean oil meal as a protein supplement for lactating cows. Stiles (1971, unpublished data), at Southern Illinois Agricultural Experiment Station, compared the effect of four different Starea products--44 percent corn-Starea, 44 percent milo-Starea, 70 percent wheat by-product-Starea, and 44 percent wheat by-product-Starea--on grain and silage intake and on milk production with lactating dairy cows. His results indicated that these Starea products could support as much as 50 pounds of milk production per day.

Starea in Growth and Finishing Trials

The value of Starea as compared to vegetable proteins has also been studied in growth and finishing trials. In a preliminary study comparing Starea, urea, and soybean meal as protein supplements in fattening rations for steers, Bartley *et al.* (1968) reported that the steers fed soybean meal had an average daily gain of 1.26 kg as compared to 1.24 kg for the Starea

group, and 1.16 kg for the urea group. Gains of Starea fed steers were therefore superior to gains of urea fed group, and only slightly less than those of soybean meal fed animals. Haskins (1968, unpublished data) compared rations containing various protein-roughage combination supplements with and without 34 percent Starea. At the end of 117 days of the trial, average daily gain of the Starea supplemented steers was found to be 1.60 kg, while that for non-Starea supplemented animals was 1.58 kg. Average feed intake for Starea and non-Starea steers were 12.05 kg and 12.00 kg respectively. Further work by Perry et al. (1969) supported the findings of Bartley and Haskins. Perry and co-workers compared the response and feed efficiency of Angus steer calves wintered in dry lot and receiving either Starea (41.3 percent protein equivalent) soybean meal (43.4 percent protein equivalent), or urea (48.3 percent protein equivalent) supplements. The results showed that average daily gains (0.48, 0.51, 0.44 kg for Starea, soybean meal and urea respectively) were not statistically different, although the urea supplemented group had the lowest daily gain and also required the most feed (7.19 kg) per 0.45 kg of gain as compared with 6.84 kg for Starea and 6.43 kg for soybean meal.

Hammack and Marion (1969) compared castor meal, Starea, cottonseed meal and urea in high concentrate rations fed to fattening beef steers and heifers for a period of 140 days. Results showed that the Starea fed group consumed the most dry matter (10.27 kg per day) and had the highest daily gain (1.31 kg). The castor meal lots had the lowest consumption (9.55 kg) and the slowest rate of gain at 1.25 kg per day. The urea and cottonseed lots were intermediate in consumption and gain.

Stiles (1971, unpublished data), at the Southern Illinois Station, evaluated 44 percent milo-urea pelleted, 44 percent infused sorghum berry, 44 percent soybean meal, 44 percent Starea and 60 percent Starea protein

supplements in a concentrate finishing trial with beef cattle. Average daily gain for the lots under the respective treatment were reported as 1.35, 1.34, 1.44, 1.42 and 1.32 kg. It was observed that the infused milo berry lot consumed grain quite slowly and the 44 percent Starea group essentially did not gain any weight from 56-70 days on test. They noticed that subsequent gains, however, indicated that a longer feeding period might have favored this group. Tucker and Harbers (1972) used the same kind of protein supplements as above in a growing and finishing trial with steers of mixed breeding. Average daily gains obtained were similar but lower, 1.16, 1.14, 1.23, 1.16 and 1.23 kg for milo-urea pelleted, infused sorghum berry, soybean meal, Starea 60 and Starea 44 respectively, than the values reported by Stiles. They reported that while the Starea 44 group had similar consumption and comparable gains and feed efficiency to the soybean meal group, the group on infused milo berry supplement ate less feed and had lower gains. This appears to corroborate the findings of Stiles. Milo-urea pelleted was found to almost equal both soybean meal and Starea 44 in the growing phase, but was less efficient in the finishing phase. They observed that, when made isonitrogenous with the other supplements in the finishing phase, Starea 60 failed to give as good performance as it did during the growing phase.

Griffel (1971) conducted a wintering trial to evaluate the effect of rations supplemented with soybean meal, corn-Starea 44 and urea (281) on average daily gains and feed efficiency of crossbred (Charolais x Hereford) and Hereford calves. He observed that the calves fed the urea ration consumed less initially but increased their intake during the latter part of the trial. Good feed intakes were obtained for the soybean meal and Starea groups, and gains, 0.74 and 0.68 kg respectively, were more than for the urea group (0.65 kg). He also reported better feed efficiency for Starea (12.68) and soybean

meal (12.46) than the urea group (14.09). These results appear to be in line with the earlier findings of Haskins (1968), Bartley and co-workers (1968), and Perry and co-workers (1969).

Comparing soybean meal and Starea in a finishing study with Hereford steers, Bartley (1972) reported that Starea 60 was equal to soybean meal in palatability, average daily gains and feed efficiency. His findings were supported by Perry (1972) in a finishing study with Angus steers. Perry also reported an overall better dressing percent and larger ribeye area for Starea 60 lots, but similar cutability and variable degree of marbling. All of the above results point to the fact that Starea can satisfactorily replace soybean meal as a protein source in growing and finishing ruminant rations.

Urea, Vegetable Proteins, and Starea in Range Cattle Rations

Urea is of value in ruminant rations because it has been reasonably well-utilized in the presence of adequate supply of carbohydrate feed, such as grains, and because it can be economically used to extend the supply of natural proteins especially in fattening rations of cattle and sheep. However, researchers have had variable results in developing urea-containing protein supplements for cattle fed poor-quality forages under winter range conditions.

Murray and Romyn (1939) found that urea could successfully replace peanut cake as a protein supplement for cattle grazing Rhodesia's rangeland during the dry season. Stephens et al. (1948) found soybean pellets superior to either cottonseed cake or urea pellets for wintering mature steers on range grasses. They reported that steers on cottonseed cake outgained (41.36 kg) those on urea pellets (15.91 kg), but under severe winter conditions both cottonseed cake and urea groups lost weight. The wintering trials of Gallup

et al. (1953) with steers and heifers on native range, however, showed that steers or heifers fed 25 percent urea pellets wintered as well as those fed equal amount of cottonseed meal. Further tests, by these same workers, with pregnant beef cows also showed that these animals could be wintered satisfactorily on dry range grass with a daily supplement of 1.36 kg of the 25 percent urea pellet. They reported satisfactory performance with breeding bulls fed the 25 percent urea pellets plus varying amounts of concentrates.

The results reported by Nelson and Waller (1962) seem to differ from the above findings. These workers found that urea-containing supplements for cows on range were always inferior to isonitrogenous ones containing cottonseed meal as the supplemental nitrogen source. These latter results have been supported by the work of Williams et al. (1969) who reported that pregnant and lactating Angus cows wintered on dead range grass and fed the urea-containing supplement lost more weight than those fed cottonseed meal. They observed that although birth and weaning weights of the calves from cows on the two treatments were not significantly different, trends seemed to favor the group fed cottonseed meal. These results apparently suggest that the combination of poor quality roughage and the urea supplement could not furnish sufficient carbon skeletons for the utilization of dietary urea.

The possibility of using Starea as a protein supplement in rations for beef cattle on the range has been under investigation by some researchers. Bartley et al. (1968) compared soybean meal and Starea 34 as protein supplements for wintering Hereford heifers on bromegrass pasture. They reported no significant differences between the two treatments indicating that Starea was as efficient as soybean meal and successfully served as a protein supplement under conditions usually felt to be unfavorable to urea utilization. Subsequent work was carried out by Tucker et al. (1971, 1972) comparing Starea,

urea and soybean meal in wintering rations for non-lactating pregnant Hereford cows on Bluestem pasture. They observed similar weight changes for both the Starea and soybean meal groups. This was in accord with the earlier findings of Bartley and co-workers. Tucker and co-workers also reported similar weaning weights of calves whose dams received either soybean meal or Starea 44. These weights were heavier than weights of calves from cows in either urea-sorghum grain or sorghum grain. They found rebreeding problems to be greater with cows on urea and sorghum grain supplements. In other experiments, Brethour and Duitsman (1973) reported that supplementation of range cattle with either Starea or soybean meal from late summer to early fall did not prove to be beneficial, probably indicating that protein is not limiting at this time under this situation.

Starea Vs. Urea in Rumen Metabolic and N-Balance Studies

Adequate dietary nitrogen is essential for optimal performance of the growing animal. A deficiency of dietary nitrogen has been shown to reduce feed consumption (Egan, 1965), impair growth (Elliot and Topps, 1963a), and decrease feed efficiency (Preston, Schnakenberg and Pfander, 1965). Also, reports by Schmidt-Nielsen (1958), Topps and Elliot (1967), and Cocimano and Leng (1967) have all shown that ingested nitrogen has a marked effect on urinary nitrogen excretion.

Major factors likely to limit the quantity of non-protein-nitrogen that can be efficiently utilized in ruminant diets have already been reviewed. Johnson et al. (1942) and Hamilton et al. (1948) reported a decrease in nitrogen retention of lambs when over 50 percent of the total dietary nitrogen was added in the non-protein form. Annison and Lewis (1959) stated that the nutritive value of a protein to ruminants is affected by the degree of

degradation to ammonia in the rumen. Drori and Loosli (1961) obtained moderate rumen ammonia levels when sheep consumed diets containing soybean oil meal or urea and different carbohydrates (glucose and starch). However, high rumen ammonia values were obtained on the urea diets when the supplements were introduced through a fistula, rather than fed, further supporting the evidence that urea undergoes rapid hydrolysis in the rumen. The moderate levels of ammonia obtained on the starch or glucose urea diets when fed was probably due to the relatively slow consumption of these diets. Blackburn and Hobson (1960) and Little *et al.* (1963) also found a rapid release of ammonia leading to a loss of nitrogen from the rumen when a readily soluble nitrogen source was used. The rapid release of ammonia from the rumen has been considered by several workers to be of particular significance in the economy of non-protein-nitrogen utilization.

Starea has been credited with the slowing down of urea hydrolysis in the rumen and increasing the synthesis of rumen microbial protein (Bartley *et al.*, 1968; Helmer *et al.*, 1970a, 1970b; Stiles *et al.*, 1970). Bartley *et al.* (1968) compared Starea and urea mixed with cracked, finely ground, and expanded sorghum grain in determining rumen ammonia concentrations in fistulated twin steers. They reported that rumen ammonia levels were reduced most with Starea. The protein content of bacteria produced on Starea ration was also found to be greater than that of bacteria produced on corn plus urea. Helmer *et al.* (1970), studying the effect of Starea on rumen metabolism in cattle, reported that Starea improved urea utilization *in vitro*. They found that rumen ammonia concentration was lower with Starea than with unprocessed corn and urea after four hours of fermentation *in vitro*, indicating a more efficient conversion of ammonia from Starea to microbial protein. The results of *in vivo* experiment by Stiles *et al.* (1970) also showed that rumen ammonia

concentration was lowest with Starea when compared with cracked, finely ground, and expanded grain rations. This effect by Starea was significantly ($P < 0.01$) greater when compared with cracked grain ration, but similar to the effect of the finely ground and expanded grain rations. These results appear to support the early findings of Bartley and co-workers.

Sheihzadeh and Harbers (1972), studying the effect of expanded starch-urea products in high roughage lamb diets, reported that a more desirable nitrogen retention, growth and ruminal ammonia production was obtained when urea was processed with grain than with unprocessed urea. Starea 44 was observed to have out-performed Starea-70. The report which follows provides some additional information on the utilization of Starea-70 in beef cattle rations.

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PART II

COMPARISON OF SOYBEAN MEAL, STAREA AND UREA IN FEEDLOT SUPPLEMENTS

Introduction

The need for additional protein feeds in balancing total livestock rations is well recognized. The value of a nitrogen source in a ruminant ration is, however, dependent upon its acceptability to the animal; its toxicity and its ability to provide nitrogen which can be utilized by rumen microorganisms. Many simple compounds have been used to provide non-protein nitrogen for ruminants. The compound that has been most widely used as a cheap source of non-protein nitrogen is urea. Urea is fairly well utilized in ruminant rations containing high levels of grain and it is still an important component in fattening rations of cattle and sheep.

The full utilization of urea by ruminants is, nonetheless, still hindered by its lack of palatability, separation in mixed feeds, rapid hydrolysis to ammonia in the rumen, predisposing the animal to toxicity, and a poor nitrogen retention. To circumvent these major problems Bartley et al. (1968) developed a starch-controlled urea product called Starea--an expansion processed mixture of grain starch and urea. Since its development, Starea has been compared with soybean meal and urea in several feeding trials by various researchers (Bartley et al., 1968; Haskins, 1968; Perry et al., 1969; Helmer et al., 1970a, 1970b; Stiles et al., 1970; Hammack and Marion, 1970; Bartley, 1971; Bucholtz and Henderson, 1971; Perry, 1971; Griffel, 1971; Stiles, 1971; Tucker et al., 1971; Tucker and Harbers, 1972; Tucker et al., 1972; Perry, 1972; Sheihzadeh, 1972; Shiawoya et al., 1973). Most of these workers have

reported that Starea is approximately equal to soybean meal and superior to urea as a protein substitute. Improved palatability, increased animal weight gains, lowered rumen ammonia concentration and improved utilization of urea nitrogen in form of Starea have all been reported in favor of Starea as compared to urea-containing rations.

This experiment was conducted to study the value of Milo- or Wheat Starea (70% protein equivalent) as compared to soybean meal, soybean meal with urea (50:50) and urea as a protein supplement in growing and finishing ration for steers in feedlot. A digestibility and nitrogen balance study was carried out to further evaluate the nitrogen metabolism of steers fed rations containing three of the protein supplements used in the finishing trial.

Experimental Procedure

Trial 1. Growth and Finishing Study. One-hundred and five feeder Angus steers were purchased from Tennessee at an average weight of 186.4 kg on April, 1972. They were grown on grass on the university range until they entered the feedlot on October 19, 1972. The steers, about 18 months old and having an average body weight of 281.8 kg, were randomly allotted on the basis of body weight to 15 pens of seven steers each. Each steer was implanted with 24 milligrams of Ral-Gro, dewormed with thiabendol and treated with Co-Ral against lice and grubs. Three pens were assigned to each of the five protein supplements in their rations. The randomized complete block design is as shown in table 1. Steers on ration I received a soybean meal (SBM) supplement; ration II, a 50:50 ratio of SBM and urea (SBM-urea); ration III, all urea; ration IV, Milo Starea-70 (MS-70)* and ration V, Wheat Starea-70 (WS-70)*

*Kindly donated by Far-Mar-Co., Hutchinson, Kansas.

TABLE 1. EXPERIMENTAL DESIGN - RANDOMIZED COMPLETE BLOCK
(TRIAL 1)

Ration no.	I	II	III	IV	V
Block 1	Pen 24	26	22	23	25
Block 2	Pen 27	30	31	29	28
Block 3	Pen 33	34	35	32	36

The proportion of the ingredients in the rations was gradually changed until the animals were on full feed. The concentrate rations were formulated to contain equivalent amounts of crude protein (11.62%) and digestible energy, minerals, vitamins and additives. The supplementary nitrogen sources contributed about 21% of the total dietary protein. The animals were fed ad libitum twice daily, about 8:00 a.m. and 5:00 p.m. and water was available at all times. The ration compositions are given in table 2. The animals were weighed on the first day of the experiment and at every 28-day interval until the experiment was terminated at the end of 168 days. Average feed consumption and feedlot performance according to treatments were recorded as shown in table 4.

At the conclusion of the 168-day feeding trial the steers were weighed and shipped 193.5 Km to be slaughtered. Incidence of damaged liver was examined at slaughter. Carcass grade, marbling score, maturity and percent of kidney fat were determined by a faculty meat specialist. Fat thickness over the rib eye and area of the rib eye at the 12th rib were also measured. All measurements were made after a 24-hour cooler holding period. Adjusted final weight of each animal was obtained by dividing the hot carcass weight by a constant average dressing percentage (60.35%) of all the animals. Such

TABLE 2. PERCENTAGE COMPOSITION, DRY MATTER BASIS, OF RATIONS (TRIAL 1)

Ration No.	I	II	III	IV	V
Nitrogen Source:	SBM ^a	SBM-Urea	Urea	MS-70 ^b	WS-70 ^c
Crude protein content of ration, %	11.62	11.62	11.62	11.62	11.62
Ration Composition, %:					
Oct. 19 to Nov. 15, 1972					
Corn silage	23.17	21.68	21.68	21.68	21.68
Rolled milo	69.69	73.33	73.33	73.33	73.33
Protein supplement	7.14	4.99	4.99	4.99	4.99
Nov. 16, 1972 to Feb. 26, 1973					
Corn silage	20.06	20.06	20.06	20.06	20.06
Rolled milo	72.53	72.53	72.53	72.53	72.53
Protein supplement	7.41	7.41	7.41	7.41	7.41
Feb. 27 to Apr. 4, 1973					
Corn silage	13.48	13.48	13.48	13.48	13.48
Rolled milo	37.98	37.98	37.98	37.98	37.98
Corn	40.58	40.58	40.58	40.58	40.58
Protein supplement	7.96	7.96	7.96	7.96	7.96
Crude protein content of supplement, %	32.40	32.80	32.60	32.50	32.50
Supplemental protein, % of ration crude protein	20.66	20.91	20.78	20.65	20.65
Supplement composition, %:					
Soybean meal (44% CP)	73.65	33.40	—	—	—
Urea (28% CP)	—	5.20	9.20	—	—
Milo Starea-70	—	—	—	42.00	—
Wheat Starea-70	—	—	—	—	42.00
Ground milo	—	31.95	60.95	28.15	28.15
Limestone	15.45	14.80	15.20	15.20	15.20
Dicalcium phosphate	—	3.00	3.00	3.00	3.00
Salt	9.25	10.00	10.00	10.00	10.00
Zinc-5	1.00	1.00	1.00	1.00	1.00
Vitamin A	0.15	0.15	0.15	0.15	0.15
Aureofac 10	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00

^aSBM = Soybean meal^bMS-70 = Milo Starea-70 percent protein equivalent^cWS-70 = Wheat Starea-70 percent protein equivalent

adjustment was made to eliminate differences in fill at the time of final weight recordings. Carcass data are as given in table 4.

Trial 2. Digestibility and Nitrogen Balance Study. Six (two Hereford and four Angus) steers having an average initial weight of 410.2 kg were selected for this trial. The steers were raised on the university farm and were fed on grain and corn silage prior to the trial.

A replicated Latin square design was used in this experiment as shown in table 3.

TABLE 3. EXPERIMENTAL DESIGN OF METABOLISM STUDY

Ration No. Nitrogen Source	III Urea	IV MS-70	V WS-70
Period 1	1 ^a 2	3 4	5 ^b 6
Period 2	3 -	1 6	2 4
Period 3	4 6	2 -	1 3

^aIdentification of animal on a specific ration in a specific period.

^bSteer number 5 fell sick after the first period and was therefore eliminated from the experiment.

Two animals were assigned to each of three rations containing three different protein supplements--all urea, Milo Starea-70 and Wheat Starea-70--the same as was used in the finishing trial. Steers were placed in metabolism stalls and fed equal amounts of feed furnishing 110 gm dietary nitrogen per day. Feed

was given twice daily, one-half of the ration being fed at 8:00 a.m. and the other one-half at 5:00 p.m. Water intake was permitted ad libitum throughout the entire experiment which lasted for 42 days. A 7-day adjustment followed by a 7-day collection period was used for each of the three periods. At the termination of each 7-day period, the three diets were reassigned to the six steers. Total feces were collected daily, weighed and five percent aliquots kept frozen in polyethylene bags. Total urine was also collected daily, measured, and one percent aliquots kept in glass bottles containing 25 ml of 38% hydrochloric acid. Prior to the start of collection, 100 ml of the diluted (50:50) hydrochloric acid were added to each collection plastic bucket to prevent urinary urea hydrolysis and subsequent ammonia loss. Daily feed refusals were weighed and samples kept frozen in polyethylene bags. Samples of basal diet components (corn silage and rolled milo) fed during each period were also taken and frozen. At the end of each collection period the diet, refusals and fecal samples were composited and dried to a constant weight at 67°C. in an air drying oven for about four to five days. Samples were ground in a Wiley mill and subjected to proximate analysis according to modified A.O.A.C. (1970) methods. Composite samples of the urine were analyzed for nitrogen by the Kjeldahl method (A.O.A.C., 1970).

At the end of period one, one of the steers became sick and never recovered well enough to be used in the subsequent periods, and was therefore removed. At the termination of the experiment all the steers were taken out and their final body weights were recorded.

All data collected were analyzed by the method of least squares analysis of variance (Kemp, 1972). Duncan's new multiple range test (Fryer, 1966) was used to test differences between means whenever a significant effect was observed among treatments.

Results and Discussion

Trial 1. Growth and Finishing Study. Means of performance and carcass data are presented in table 4. Analysis indicated that daily dry matter consumption was highest on the SBM supplemented ration. Consumptions on SBM-urea, urea and MS-70 were similar and slightly lower than on WS-70, lowest intakes being on urea and MS-70. None of the differences, however, were statistically significant. Bartley et al (1968) reported greater feed consumption by dairy cows fed rations supplemented with SBM or Starea than the urea. Helmer et al (1970) compared Starea, urea and SBM as protein sources for lactating dairy cows and observed that cows fed grain rations supplemented with either SBM or Starea (23% crude protein) consumed more grain and produced more milk containing more protein than cows fed the same grain ration supplemented with urea. They also found that Starea was nearly equal to SBM as a protein supplement. In this study feed consumption on urea supplemented ration was one of the lowest, probably a palatability problem, resulting in lower daily gain (0.88 kg). During the first half of the study, steers on urea supplemented ration made the lowest gain, but compensated for it during the second half indicating a gradual adjustment to the ration. In a wintering trial, Griffel (1971) found that animals fed urea supplemented ration consumed less feed initially but increased their intake during the latter part of the trial. Several studies had previously shown that animal performance improves with time on urea-containing rations (Owen et al., 1943; Campbell et al., 1963; King et al., 1965).

Milo Starea-70 ration supported greater daily gain (0.94 kg) than WS-70 (0.88 kg) and urea (0.88 kg), but less than SBM (0.96 kg). These values, however, were not statistically significant ($P>.10$). SBM-urea

TABLE 4. MEANS AND STANDARD ERRORS OF FEEDLOT PERFORMANCE AND CARCASS TRAITS OF STEERS FED RATIONS CONTAINING FIVE DIFFERENT NITROGEN SOURCES FOR 168 DAYS (TRIAL 1)

Ration No.	I	II	III	IV	V
Nitrogen Source:	SBM	SBM-Urea	Urea	MS-70	WS-70
Feedlot data	20	20	19	21	20
No. steers	283.70	279.30	280.90	284.00	281.80
Initial weight, kg	444.44 ± 6.57 ¹	438.08 ± 6.59	430.08 ± 6.74	440.17 ± 6.39	429.86 ± 6.57
Final weight, kg ²					
Daily dry matter consumed, kg	9.63 ± 0.34	9.07 ± 0.35	9.05 ± 0.33	9.04 ± 0.34	9.11 ± 0.33
Total gain, kg	161.84 ± 6.68	155.09 ± 6.68	146.91 ± 6.86	157.90 ± 6.52	147.09 ± 6.68
Daily gain, kg	0.96 ± 0.04	0.93 ± 0.04	0.88 ± 0.04	0.94 ± 0.04	0.88 ± 0.04
Dry matter per 0.45 kg gain	9.51 ± 0.41	9.89 ± 0.42	10.08 ± 0.40	9.50 ± 0.41	10.03 ± 0.40
Feed cost per 45.5 kg gain ³	\$20.13	\$19.45	\$18.23	\$17.77	\$18.89
Carcass data					
Hot carcass weight, kg	268.17 ± 4.74	264.95 ± 4.75	253.78 ± 4.86	265.56 ± 4.61	259.31 ± 4.74
Rib eye area, cm ²	72.11 ± 1.74	67.79 ± 1.75	69.77 ± 1.79	74.25 ± 1.70	73.61 ± 1.74
Fat thickness over rib eye, cm	1.22 ± 0.08	1.16 ± 0.08	1.23 ± 0.09	1.12 ± 0.08	0.98 ± 0.08
Kidney knob, %	3.49 ± 0.16 ^a	2.81 ± 0.16 ^b	3.27 ± 0.17 ^a	3.38 ± 0.16 ^a	3.25 ± 0.16 ^a
Maturity score ⁴	2.00 ± 0.14	1.87 ± 0.14	2.25 ± 0.14	2.29 ± 0.13	2.01 ± 0.14
Marbling score ⁵	16.71 ± 0.88	15.27 ± 0.89	17.08 ± 0.91	16.56 ± 0.86	16.07 ± 0.88
Yield grade ⁶	3.07 ± 0.14	3.06 ± 0.14	3.03 ± 0.15	2.81 ± 0.14	2.63 ± 0.14

¹*Mean ± Standard error.

²Final weight = hot carcass weight ÷ average yield of 60.35%.

³Cost of grain, silage and supplement only using following values per 909 kg: milo \$38.80, silage \$10, soybean meal \$166, urea and Starea \$100.

⁴Maturity score - A = 1, 2, 3; B = 4, 5, 6.

⁵Marbling score - Small = 13, 14, 15; Modest - 16, 17, 18; Moderate - 19, 20, 21.

⁶Yield grade - Most desirable = 1; Least desirable = 5.

a-b Horizontal values with differing superscripts on same line differ significantly (P < .05).

supplemented group had about equal daily gain (0.93 kg) as the MS-70 fed group, while WS-70 and urea fed groups were observed to have the same daily gains (0.88 kg). In their experiment with steers, Bartley et al. (1968) found that steers fed rations supplemented with Starea had gains (1.24 kg) superior to those of urea fed group (1.16 kg) and only slightly less than those of SBM fed steers (1.26 kg). Perry et al. (1969) however reported non-significantly lower average daily gains of 0.48, 0.51 and 0.44 kg for Starea (41.3% protein equivalent), SBM (43.4% protein equivalent) and urea (48.3% protein equivalent) respectively when these supplements were used in rations for wintering steers in dry lot. Griffel (1971) observed similarly lower gains of 0.74, 0.68 and 0.65 kg on SBM, Starea and urea respectively in a wintering ration for calves. In a finishing trial with beef cattle Stiles (1971) reported gains of 1.35, 1.34, 1.44, 1.42 and 1.32 kg on rations supplemented with 44% milo-urea pelleted, 44% infused sorghum berry, 44% SBM, 44% Starea and 60% Starea respectively. These figures were slightly higher than those obtained by Bartley et al. (1968). However, gains similar to those obtained by Bartley et al., but lower than those obtained by Stiles (1971) were indicated by the growth and finishing experiment of Tucker and Harbers (1972) using the same kind of supplements used by Stiles (1971). Tucker and Harbers (1972) obtained daily gains of 1.16, 1.14, 1.23, 1.16 and 1.23 kg on milo-urea pelleted, infused sorghum berry, SBM, Starea-60 and Starea-44 supplemented rations respectively. The values reported in this study, although lower than those reported by Bartley et al. (1968), Stiles (1971) and Tucker and Harbers (1972), were higher than those reported by Perry et al. (1969) and Griffel (1971). The apparent differences could have been due to slight differences in the rations and experimental conditions. When this trial is considered against the inclement weather conditions at the time, the steers' performance could be

said to be satisfactory. A negative correlation was usually observed between feed consumption and temperature change across treatments. Feed consumption nearly always increased with drop in temperature. This was probably indicative of an attempt by the animals to expend useful energy in maintaining basal metabolic processes, perhaps at the expense of gain, under conditions that probably reduced the possibility of better response to a minimum. On the whole the values obtained in this trial reflected the same general trend.

Feed efficiency on SBM (9.51) and MS-70 (9.50) rations was almost equal and although the values were better than those of SBM-urea (9.89), urea (10.08) and WS-70 (10.03) fed groups, the differences were not significant ($P>.10$). However, the urea supplemented group which had the lowest daily gain, similar to WS-70, also required the most feed per 0.45 kg of gain. These findings seemed to support the observations of other workers. Perry et al. (1969) reported that, while there were no significant differences in daily gain between Starea, SBM and urea supplemented rations fed to calves wintered in drylot, urea supplemented animals had the lowest daily gain and also required the most feed (7.19 kg) per 0.45 kg feed as compared with 6.84 kg on Starea and 6.43 kg on SBM. Bartley (1971) observed that Starea 60 was equal to SBM in palatability, average daily gain and feed efficiency (8.86 on Starea and 8.50 on SBM). Griffel (1971) found better feed efficiency on Starea (12.68) and SBM (12.46) supplemented rations as compared with urea (14.09) fed to calves in a wintering trial. Perry (1972) compared SBM and Starea 60 supplemented rations fed to finishing steers and reported no significant differences in feed intake, average daily gain or feed efficiency (9.33 on Starea and 8.85 on SBM). However, in an earlier experiment with yearling steers those on SBM supplemented ration out performed (6.98 feed efficiency) all other groups. Among the non-protein nitrogen supplemented groups, feed

efficiency was better on the urea group (7.25) followed by Starea (7.66) and biuret (7.86). These latter results differ from those of other workers cited above and from the findings in this study on SBM, urea and Starea.

Cost of gain figures favored the MS-70 group probably due to the comparatively good performance of these cattle and the fact that Starea was valued at \$100 per 909 kg or equal to the cost of urea and less than that of SBM (\$166 per 909 kg). The cost of gain on both SBM and SBM-urea supplemented rations was higher than others perhaps due to the high cost of SBM at the time. In their fattening trials with steers, Hammack and Marion (1970) reported lower feed cost per 45.5 kg gain on urea (\$17.67) as compared with Starea (\$18.44). Starea and urea were valued at \$65 and \$68 per 909 kg respectively. Bucholtz and Henderson (1971), in similar experiment with steers, also found lower cost of gain on urea (\$15.08) as compared with Starea (\$17). The cost of Starea and urea per 909 kg was indicated as \$80 each. These results differ slightly from those obtained in this study. This might have been due to differences in cost of feeds and animal performance. Since there was no significant differences among the rations in total performance, a farmer might be better off with the cheaper rations such as the MS-70, under the conditions of this trial, provided the cost of Starea and other feeds stayed reasonable.

Only three cases of condemned liver, one each from SBM-urea, MS-70 and WS-70 groups, were observed. Carcass data were rather similar among the five groups. Percent kidney fat was the only value significant, being lowest ($P < .05$) in the group fed the SBM-urea supplemented ration. F-test indicated significant ($P < .10$) differences in rib eye area; however, when data was subjected to Duncan's new multiple range test (Fryer, 1966) no significant differences were observed. Maturity score closest to desirable and lowest

marbling score, although not significantly different from the others, were from the SBM-urea supplemented group. This group had the lightest initial weight and these results, therefore, probably indicate that feed was used to lay on more muscle tissue rather than fat. Hammack and Marion (1970) found no significant differences in carcass data among four groups of beef steers and heifers fed Starea, urea, castor meal and cottonseed meal supplemented rations. Bucholtz and Henderson (1971) reported no difference in any of the carcass traits between steers fed on SBM, urea, Starea and biuret supplemented rations. In his finishing study with SBM and Starea 60 supplemented rations, Perry (1972) observed larger rib eye areas for the Starea animals and variable degree of marbling and yield grade. A similar trend was indicated by the results of this study which showed that steers receiving the Starea-70 supplements had larger rib eye muscle and good marbling and therefore tended to grade somewhat higher. Thus, Starea-70 groups would appear to bring in more profit if the animals were sold on yield grade basis.

The over-all performance of the steers on the various nitrogen supplemented rations used in this growth and finishing study, though showed some apparent differences, most of these differences were not statistically significant. It is generally considered that it is only during the early stages of growth that the animal's protein requirement is greater than that which is supplied by the microorganisms normally produced in the rumen (Ørskov, 1971). The steers used in this study came into the feedlot at an average weight of 281.82 kg. According to the National Research Council requirements (1970), a 282 kg finishing steer needs 11.1% total protein and 7.2 kg dry matter intake per day. In this trial the total protein content of the rations was 11.62%, the lowest dry matter intake being 8.70 kg per day. Putnam et al. (1972) stated that finishing rations need not contain more than

8 to 9% crude protein for animals from 360 kg to slaughter weight, indicating that supplemental protein would perhaps not be needed in commonly used high-grain finishing rations. Preston (1973) reported that 11.4% crude protein was adequate when 6.82 kg of corn silage was fed daily in the ration, and that carcass traits were unaffected by either the form of corn, level of silage, or level of supplemental protein fed. The level of corn silage in the rations in this experiment ranged from 6.27 to 7.03 kg. Preston (1973) found that, generally, feedlot performances and carcass quality were essentially the same whether steers received supplemental protein for only the first 56 or 112 days of the feeding period or received supplemental protein all the way to market weight. Other researchers (Reid, 1953; Repp *et al.*, 1955; Helmer and Bartley, 1971) had previously indicated that, on the whole, when non-protein nitrogen compounds, such as urea, replace up to 15 to 45% of the total crude protein content of the fattening ration they are similar in performance to the conventional proteins such as SBM. In the present study, the non-protein nitrogen supplements replaced about 21% of the total crude protein of the ration. The performance and carcass data obtained seems to indicate that any of the non-protein nitrogen sources (urea and Starea 70) could suitably replace SBM as a protein supplement. When considered from the standpoint of the cost of gain and yield grade, MS-70 might be a more economical protein supplement under the conditions of this trial.

Trial 2. Digestibility and Nitrogen Balance. The results of metabolism trial are presented in table 5. Kemp's (1972) least squares method of analysis was used on these data because of the two missing observations as indicated in table 3. Urea and WS-70 fed steers had higher dry matter and energy digestibility (not statistically significant) than MS-70, probably due to the higher total digestible nutrient content of their rations. Similarly,

TABLE 5. MEANS AND STANDARD ERRORS OF APPARENT DIGESTIBILITY AND NITROGEN BALANCE OF STEERS FED RATIONS CONTAINING THREE OF THE FIVE PROTEIN SOURCES USED IN TRIAL (TRIAL 2)

Ration No. Nitrogen Source:	III ^a Urea	IV ^a MS-70	V ^b WS-70
Number of observations	5	5	6
Dry matter intake, gm daily	5120.22 ± 307.09	5045.57 ± 307.09	4875.31 ± 250.74
Total digestible nutrient, % in ration	72.46 ± 0.06	69.70 ± 0.06	73.67 ± 0.05
Digestibility, % intake			
Dry matter	76.52 ± 1.38	72.57 ± 1.38	77.23 ± 1.12
Organic matter	77.77 ± 1.48	73.94 ± 1.48	78.33 ± 1.21
Crude protein	59.92 ± 2.94	55.50 ± 2.94	65.83 ± 2.40
Non-protein organic matter	80.22 ± 1.37	76.77 ± 1.37	80.42 ± 1.12
Ether extract	62.38 ± 5.67	61.55 ± 5.67	58.78 ± 4.63
Crude fiber	53.27 ± 2.00	54.82 ± 2.00	53.72 ± 1.63
Nitrogen free extract	83.29 ± 1.13	79.60 ± 1.13	84.05 ± 0.92
Energy	74.02 ± 1.43	70.00 ± 1.43	73.47 ± 1.17
Nitrogen balance			
Intake, gm	98.64 ± 2.61	101.78 ± 2.61	107.98 ± 2.13
Fecal, gm	39.06 ± 3.54	44.76 ± 3.54	36.42 ± 2.89
Absorbed, gm	59.58 ± 3.36	57.02 ± 3.36	71.56 ± 2.74
Urine, gm	47.36 ± 4.50	38.87 ± 4.50	48.72 ± 3.67
Retained, gm	13.72 ± 4.08	18.16 ± 4.08	22.86 ± 3.33
Retained, % intake	14.25 ± 4.19	17.82 ± 4.19	21.37 ± 3.42
Retained, % absorbed	19.15 ± 5.50	32.64 ± 5.50	29.19 ± 4.49

^aEach value is the mean of five observations.

^bEach value is the mean of six observations.

organic matter, crude protein, non-protein organic matter and nitrogen free extract digestibility all tended to be higher on urea and WS-70 than MS-70. The high energy intake by the urea group and higher metabolizable energy of wheat (3.18 M cal/kg), as compared to milo (2.89 M cal/kg), in the WS-70 group probably accounted for these differences. Bloomfield *et al.* (1958) reported differences in urea utilization *in vitro* with starches from different sources. These workers found that while corn starch supported 98% urea utilization, wheat starch, potato starch and soluble starch supported 81, 63 and 55% utilization respectively.

Crude fiber and ether extract digestibilities were similar across treatments. Sheihzadeh (1972) reported lowered digestibilities for high-cooked sorghum-Starea 44 when compared with SBM supplemented rations fed to lambs in a metabolism study. Hale *et al.* (1963), Saba *et al.* (1964), Keating *et al.* (1965) and Oltjen *et al.* (1967) have found that, when compared with other cereal grains, milo protein is poorly digested by steers. Other researchers (Pearson and Smith, 1963; McNaught and Smith, 1947) indicated that the nature of the protein in a ration may affect the efficiency at which urea is utilized. The milo in the experimental rations might have been important in influencing the utilization of the nitrogen, since it provided the major part of the remaining ration nitrogen. The lower total digestible nutrient and energy digestibility of the MS-70 also probably reflected the lower crude protein digestibility, though not significantly, by this group. In the nitrogen balance experiment with lambs, McLaren *et al.* (1965) found that the utilization of non-protein nitrogen in semi-purified diets was related to both its energy level and the duration of time the animals were on diet. In this present study analysis showed that there was significant increase in nutrients' digestibility with period ($P < .05$) for all nitrogen sources,

probably suggesting adaptation to both stall-stress and the ration constituents.

No statistically significant differences ($P>.10$) were observed in nitrogen retention of steers on any of the diets. However, the urea fed group had the least amount of nitrogen retained and possibly explains the low rate of gain in the performance data, because less nitrogen is available for tissue utilization. The increase in protein digestibility without an increase in nitrogen retention is probably due to an increase in urinary nitrogen. The reduced nitrogen intake might have also contributed to the apparently lower nitrogen retention (Ammerman et al., 1972). Nitrogen retentions on both MS-70 and WS-70 were similar, despite somewhat higher digestible protein on WS-70. But again, a higher urinary nitrogen was observed on WS-70. It was also probable that any possible marked increase in nitrogen retention might have been repressed due to slightly lower feed consumption. There was a significant decrease ($P<.05$) in urinary nitrogen which resulted in significant increase ($P<.05$) in nitrogen retention with period for all nitrogen sources suggesting adaptation to the rations. When expressed as percent intake and absorbed, retained nitrogen was also observed to increase significantly ($P<.05$) with period, but both values were lowest on the urea ration. In a 72-day metabolism study with lambs, Schaadt et al. (1966) found increased nitrogen and biological value with time. In this study, time and treatment interaction was significantly ($P<.10$) noticeable on nitrogen retained and as percent of intake, and nitrogen retained ($P<.05$) as percent absorbed.

On the whole the results of trial 2 seemed to be in agreement with those of trial 1, in which no significant differences were observed among treatments in animal performance and, except for kidney knob, in the carcass data. However several trends were apparent.

Summary

A growth and finishing trial and a digestibility and nitrogen balance study were conducted to compare the effects of soybean meal (SBM), Starea (a processed intimate mixture of gelatinized starch and urea) and urea as practical feedlot supplements. In trial 1, five rations supplemented with SBM, SBM-urea (50:50 ratio), urea, MS-70 and WS-70 were made isonitrogenous and isocaloric. The supplementary nitrogen sources contributed about 21% of the total dietary protein. None of the cost and performance characteristics examined showed any statistically significant differences ($P > .10$). However, certain trends were evident. Steers on SBM were observed to have higher dry matter consumption, while consumption on SBM-urea, urea and MS-70 were similar but slightly lower than on WS-70. Steers on urea and MS-70 rations had the lowest intake. Average daily gains tended to be greater on SBM followed by MS-70 and SBM-urea with gains on urea and WS-70 being equal and lower than the others. Feed conversion on SBM and MS-70 was almost equal and better than on SBM-urea, urea or WS-70. Steers on urea were least efficient in feed conversion. Cost of gain was in favor of MS-70, with SBM and SBM-urea being most expensive, while urea and WS-70 had intermediate costs. Except for the percent kidney fat which was significantly lower ($P < .05$) on SBM-urea, all other carcass traits examined were similar on all rations. However, steers on MS-70 had larger rib eye muscle, good marbling and therefore tended to grade higher.

The metabolism study showed that both WS-70 and urea supplemented rations had higher crude protein digestibility but also higher urinary nitrogen excretion leading to a decrease in nitrogen retention. Least amount of nitrogen retained was observed on the urea ration. Nitrogen retention values were similar on both MS-70 and WS-70, though slightly higher on the later.

None of the above differences were significant. Significant decrease ($P < .05$) in urinary nitrogen and a concomitant increase ($P < .05$) in nitrogen retained was observed with period for all nitrogen sources. Likewise, period and treatment interaction was significantly ($P < .10$) noticeable on nitrogen retained. No significant differences were obtained for all the other nutrient digestibility values examined.

The results of these trials indicate that, under similar experimental conditions, the non-protein nitrogen sources investigated can suitably replace SBM as protein supplements in practical feedlot rations, with cost of gain and yield grade tending to favor MS-70.

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COMPARISON OF SOYBEAN MEAL, STAREA
AND UREA IN FEEDLOT SUPPLEMENTS

by

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A growth and finishing trial and a digestibility and nitrogen balance study were conducted to compare the effects of soybean meal (SBM), Starea (a processed intimate mixture of gelatinized starch and urea) and urea as practical feedlot supplements. In trial 1, five rations were supplemented with SBM, SBM-urea (50:50 ratio), urea, Milo Starea-70 (MS-70, containing 70% protein equivalent) and Wheat Starea-70 and contained equivalent amounts of crude protein (11.62%) and digestible energy. The supplementary nitrogen sources contributed about 21% of the total dietary protein.

One-hundred and five feeder Angus steers having an average initial body weight of 281.8 kg were randomly allotted to 15 pens of seven steers each. Three pens were assigned to each of the above five protein supplements in their rations. At the conclusion of the 168-day finishing trial, performance and carcass data were analyzed. None of the differences tested were statistically significant ($P > .10$). Dry matter consumption and average daily gains tended to be greater on SBM supplemented ration. Consumptions and gains on WS-70, SBM-urea, urea and MS-70 were similar though MS-70 was observed to be higher than the others in gains and almost equal to SBM. Feed conversion on SBM and MS-70 was about equal and better than on SBM-urea, urea or WS-70. Steers on urea were least efficient in feed conversion. Cost of gain was lower on MS-70 while SBM and SBM-urea appeared to be more expensive, with urea and WS-70 being intermediate in costs. Carcass analysis showed percent kidney fat to be significantly lower ($P < .05$) on SBM-urea. All other traits were similar on all rations. However, larger rib eye muscle and good marbling score were indicated by steers on MS-70. These steers also tended to grade higher.

In the metabolism study (trial 2), six steers, having an average initial body weight of 410.2 kg were assigned to each of three rations

supplemented with all urea, MS-70 and WS-70 (the same as was used in the finishing trial) in a replicated 3 x 3 Latin square design. The results obtained showed higher protein digestibility on urea and WS-70, but also higher urinary nitrogen leading to a decrease in nitrogen retention. Least amount of nitrogen was retained on the urea ration. Nitrogen retained was slightly higher on WS-70 than on MS-70. None of the above differences however, were significant ($P > .10$). There was significant increase ($P < .05$) in nitrogen retention as a result of decrease ($P < .05$) in urinary nitrogen with period for the three nitrogen sources. Consequently, period and treatment interaction was found to be significant ($P < .05$) on nitrogen retained. All other digestibility values examined showed no significant ($P > .10$) differences.

The results of these trials seem to indicate that the non-protein nitrogen sources used can usually satisfactorily replace SBM as protein supplements in practical feedlot rations. The cost of gain and higher yield grade were observed to favor MS-70.