THE VALUE OF CERTAIN PROTEIN AND MINERAL SUPPLEMENTS AND SPECIES OF GRASSES FOR WINTERING STEERS

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INTRODUCTION

The wintering of beef cattle at a maintenance level, or to make moderate gains, on native range forage is of particular importance to the cattle producer in the southwest. For a number of years, ranchmen have recognized the need for supplementing native range grass during the winter months with protein and minerals in order to profitably winter cattle.

The protein supplement most commonly used in this area during the past half-century has been cottonseed meal or cake. However, soybean meal has recently become available in large quantities. The increased acreage planted to soybeans in the midwest and south often makes it possible to sell the oil meal at a price equal to, or lower than, cottonseed meal. A number of experiments have been conducted comparing the nutritive value of cottonseed and soybean oil meals and the results thus far indicate that in certain types of rations soybean meal is slightly superior. Further, the results suggest that the nutritive value of soybean meal may be increased by the addition of bone meal, and that the addition of a trace mineral mixture may be beneficial.

In wintering cattle on dry, native grass, the cost of the protein supplement may amount to as much as two-thirds the total wintering cost. Proper selection of protein supplements and their improvement through the addition of minerals may greatly increase the profit from wintering cattle on native grass. The relative value of the various protein supplements now available in the southwest warrants further study. Quality of protein for cattle has been considered of little consequence. However, differences in gains made by cattle fed a maintenance ration and supplemented with various proteins indicates that quality of the protein

may be of some importance.

The different methods used in processing cottonseed to obtain oil results in oil meals which differ in composition and may also differ in nutritional value. Cottonseed meal is higher in fat content when processed by the pressure methods (hydraulic press and screw press) than by the recently developed method of pre-press solvent-extraction. The effect of the low fat content of the solvent-extracted meals on the performance of beef cattle wintered under range conditions has not been fully determined.

Cattlemen have believed for a number of years that the so-called "short" grasses (buffalo and gramas) are superior to "tall" grasses (bluestems, Indian and switch) for wintering cattle. This has also been concluded from research conducted in different areas of the state and varying climatic and soil conditions. It was possible in the experiment reported herein to study the relative value of "short" and "tall" grasses for wintering steers under the same climatic conditions.

In the range areas, much interest has been shown in the practice of self-feeding a salt and cottonseed meal mixture in which the salt content is used to control the intake of the protein supplement for wintering cattle. This practice is receiving much attention of late due to the shortage of skilled labor. However, information on the advisability of such a practice in this area is limited.

To further study some of these nutritional problems, an experiment involving three wintering trials (1950-53) was conducted at the Ft. Reno Experiment Station, El Reno, Oklahoma, with yearling and two-year-old steers grazing dry, native, range grass.

REVIEW OF LITERATURE

No attempt has been made to thoroughly discuss all the work conducted during the past half-century on the relative value of various protein and mineral supplements for beef cattle. In this review, only the experiments which apply to the specific problems involved in this study have been cited. Morrison (1950) and Snapp (1952) have extensively reviewed the literature pertaining to the value of various protein supplements for beef cattle.

The Relative Value of Various Protein and Mineral Supplements for Beef Cattle

Morrison (1951) summarized the results of 18 experiments with protein supplements for beef cattle and concluded that soybean meal was slightly superior to cottonseed meal.

Rush et al., (1931) compared soybean meal to cottonseed meal in fattening rations for beef calves and found soybean meal and cottonseed meal to be of equal value. They also found that soybean meal was superior to both whole and ground soybeans as a protein supplement.

McCampbell and associates (1941) in three trials with beef calves and yearlings wintered on sorghum silage, 1.0 pound of protein supplement and salt free-choice, found that cottonseed meal produced slightly greater gains than soybean meal.

In experiments at the Nebraska station, Brouse et al., (1944) studied the value of cottonseed meal and soybean meal without mineral supplements and when each was supplemented with a mineral mixture. The calves were fed prairie hay ad. lib. plus 1 pound of protein supplement and salt free-choice. In the trials in which no mineral supplement was fed, cottonseed meal produced greater winter gains than did the soybean meal; however, examination of their data shows a greater variation in

the gains made by steers receiving cottonseed meal as compared to those receiving soybean meal. When a mineral supplement of 4 parts steamed bone meal, 4 parts ground limestone and 2 parts salt was fed with the soybean meal at the rate of 0.1 pound per head daily, average winter gains were increased by 30 pounds per head over the group fed soybean meal without additional mineral. They obtained an increase of only 7 pounds per head from adding the same mineral mixture to cottonseed meal. It would appear from the results of this experiment that the phosphorus requirements of the calves fed the unsupplemented soybean meal were not met and hence additional mineral was beneficial.

Ross et al., (1950) at Oklahoma station conducted a four-year study to determine the value of adding mineral supplements to soybean cake for two-year-old steers wintering on dry range grass. Four lots of 18 steers each were used. All steers received 2.5 pounds of soybean cake and salt free-choice. The steers in lot 1 received no mineral supplementation while steers in lot 2 received a mineral mixture of equal parts salt, bone meal and ground limestone, free-choice. Lot 3 steers received a mixture of three parts salt and one part bone meal, free-choice. Lot 4 steers were fed .09 pounds of bone meal on top of the soybean cake. The steers in lots 2 and 3, which had free access to a mineral mixture, made greater gains than those receiving no mineral other than salt. The difference in gains of steers receiving a mineral mixture as compared to those which did not was statistically significant. In further trials, these workers were able to obtain a slight increase in gains of steers receiving soybean cake plus bone meal as compared to those receiving soybean cake alone. The difference in gains made by the steers was not significant, but followed the same trend as observed in the previous

study. In further trials the value of soybean cake, cottonseed cake and urea pellets (25 percent of the nitrogen as urea) were compared as supplements to dry, native grass for wintering two-year-old steers. The steers receiving soybean cake made significantly greater gains than the steers fed equal amounts of cottonseed cake. No minerals, other than salt, were fed in these studies.

Three years' work at the Southern Great Plains Field Station by Savage et al., (1937-50) showed that the addition of 1 part bone meal to 3 parts salt fed free-choice did not improve the gain of steers wintered on dry, native grass and cottonseed meal. When the protein supplement fed was relatively low in phosphorus (for example, soybean meal), the extra phosphorus supplementation was profitable.

Work by Gilbert (1948), Mitchell (1947), and Plumlee and Beeson (1953) on the mineral requirements of farm animals suggest that a phosphorus deficiency may occur more often in cattle than in any other class of livestock. When the phosphorus content of the roughage consumed falls below 0.12 percent, additional phosphorus is needed in the ration. It is believed that the calcium and phosphorus ratio should approximate 2 to 1 since calcium and phosphorus appear in the body at about this ratio. In rations composed mostly of roughage, the need for calcium supplementation has not been shown. In the case of phosphorus, however, when the ration is high in roughage and the protein supplement used is relatively low in phosphorus, additional phosphorus may be required.

It has been known for some time that quality of protein is important for simple stomached animals. Almquist (1944) found that s mixture of 1 part sesame meal and 2 parts soybean meal gives a protein of highest

quality as measured by the growth response of chicks. At a ratio of 7 parts sesame meal and 13 parts soybean meal, maximum growth of chicks was obtained. No results are available as to the value of such a mixture for wintering beef cattle.

From the differences observed in the weight gains of wintering steers fed different protein supplements, Ross (1950), suggested that quality of protein may be more important with cattle than has been generally believed. However, in their studies, urea pellets containing 25 percent of the nitrogen as urea were equal in value to cottonseed cake when fed at the same level.

In experiments at the Kansas station McCampbell (1941) found that corn gluten meal was equally as valuable for wintering calves and yearlings as was cottonseed meal. They also found corn gluten meal to be slightly superior to soybean meal as a protein supplement fed to calves wintered on a full feed of silage plus 1.0 pound of protein supplement per head daily and salt free-choice.

Morrison (1951) reported that in four New York experiments with fattening yearling cattle using linseed meal, soybean meal and corn gluten meal, the latter supplement was inferior to either the linseed or soybean meal.

Anderson et al., (1928-29) studied the relative value of linseed meal, corn gluten meal, cottonseed meal and various combinations of these protein supplements in fattening rations. They found that the average daily gains were greatest for steers receiving linseed meal followed by those fed corn gluten meal and those fed cottonseed meal. When the meals were fed in combination, the daily gains were greatest when a mixture of one-half linseed meal and one-half corn gluten meal was fed. A mixture of equal parts of linseed and cottonseed meal ranked

second in daily gains, followed by a mixture of equal parts of linseed, cottonseed and corn gluten meals.

Linseed meal has been widely used in rations for show cattle as well as in fattening rations for cattle in dry lot. Morrison (1951) reported that in fattening rations, a mixture of equal parts of linseed meal and cottonseed meal produced gains equal to those obtained with linseed meal alone. However, in trials where the protein supplements were fed alone, linseed meal was superior to cottonseed meal.

McCampbell and Aicher (1939) in a wintering ration consisting of sorghum silage and protein supplement found that 1.0 pound of linseed meal as a protein supplement was of less value than one pound of cottonseed meal.

From the work that has been conducted to date on the relative value of various proteins of plant origin for beef cattle, it would appear that a slight difference may exist between common oil meals in fattening rations, but that in maintenance-type rations this difference has not been consistently demonstrated. There is some disagreement in the results of experiments to date as to the value of cottonseed meal and soybean meal as protein supplements for wintering beef cattle. There is strong evidence that soybean meal requires extra phosphorus supplementation when the roughage fed cattle is relatively low in phosphorus.

The Addition of Trace Minerals to Beef Cattle Rations

Maynard (1951) has summarized the results of a number of experiments on the importance of mineral supplementation and concluded that with the exception of certain conditions, the only minerals needed are salt, calcium, phosphorus and iodine in the rations commonly fed to cattle beyond the suckling stage. It is recognized that there are certain areas where cobalt and copper should be added to the ration, however, these areas appear to be limited and rather sharply defined. The feeding of supplemental minerals that have not been shown to be deficient in the feeds common to the region appears to be an unsound nutritional practice.

Bentley and co-workers (1952), studying the trace mineral requirements of fattening cattle, compared alfalfa ash, a trace mineral mixture (cobalt, zinc, manganese, copper and iron) and reduced iron as supplements to a ration consisting of urea, cerelose, iodized salt, calcium carbonate, di-calcium phosphate, vitamin A and D oil, corn-and-cob meal and poor-quality timothy hay. The alfalfa ash and the trace mineral mixture produced a 43 percent increase in average daily gains. Iron fed alone was of no value. They concluded that none of the supplements improved the digestibility of the ration, but that the steers receiving trace minerals and alfalfa ash required 12 percent less corn-and-cob meal per 100 pounds of gain. They also noted a 25 percent increase in the daily intake of corn-and-cob meal in the mineral-fed lots.

Chappell and associates (1952), working with sheep at the Oklahoma station, found that the average digestibility of all the nutrients in a corncob basal ration was increased by the addition of alfalfa ash. They found that the apparent digestibility of organic matter and crude

fiber were significantly increased. However, these workers were unable to show a measurable increase in apparent digestibility when lambs were fed the basal ration supplemented with a mineral mixture containing Na, K,Cl, Mn, Zn, Fe and Cu.

Nelson and associates (1951) were unable to show a beneficial effect from the addition of a trace mineral mixture to the ration of growing heifers in southeast Oklahoma. The ration contained 1.25 pounds of corn gluten meal and prairie hay ad lib., and supplied 2.5 grams of phosphorus per 100 pounds of body weight. Manganese was included in the trace mineral mixture in this trial.

Totusek et al., (1953), in southeastern Oklahoma, obtained an increase of 23 pounds in the average weaning weight of calves from cows grazed year-long and receiving trace minerals in the salt and phosphorus in their drinking water. Manganese was not included in the trace mineral mixture since chemical analysis indicated that a relatively high manganese content was present in the native grass in that area of the state.

Gallup et al., (1952) at the Oklahoma station, conducted mineral balance studies with steer calves to determine the effect of a high manganese intake on the calcium and phosphorus metabolism of beef cattle. They found that as the manganese level was increased to 250, 500, 1,000 and 2,000 parts per million in the ration, phosphorus excretion was increased in the feces at all levels. Calcium excretion was increased only at the two highest levels. Calcium and phosphorus balances were positive at the 250 and 500 parts per million manganese levels of intake but not at the 1,000 and 2,000 parts per million levels. Plasma calcium and phosphorus levels were unaffected by the different intakes of manganese.

Totusek and associates (1953) in further studies on the effect of high manganese intake fed four lots of beef cows supplemental manganese as follows: Lot 1, no manganese; lot 2, 250 parts per million of manganese in the ration; lot 3, 500 parts per million of manganese, and lot 4, 500 parts per million of manganese plus 400 milligrams of iron and 40 milligrams of copper per head daily. All cows were fed prairie hay and corn gluten meal as the protein supplement. The different levels of manganese were fed year-long. They found from the analysis of eight monthly blood samples taken during the trial that the cows in lot 3 had lower levels of plasma phosphorus during the summer grazing season and made considerably less gain during the summer season than cows in lots 1, 2, and 4. The lot 1 cows produced calves with highest average weaning weight, while calves from cows of lot 2 had the lowest average weaning weight. Three of the 30 cows in lots 3 and 4 aborted during the winter period.

Glendening and co-workers (1952) at the Kansas station have studied the mineral content of feeds common to that area. The results obtained with certain feeds are shown in the following table.

Average Mineral Content of Feeds
(Moisture Free Basis)

	Ca	Mg	P	Fe	Cu	Co	Mn	Mo
Feeds	%	%	%	%	P.P.M.	P.P.M.	P.P.M.	P.P.M.
Soybean Meal	0.23	0.26	0.72	.016	20.	.21	43.	2.4
Cottonseed Meal (Hydraulic)	0.15	0.56	1.27	.017	20.	.27	25.	3.7
Cottonseed Meal (Solvent)	0.11	0.37	1.29	.015	22.	.32	24.	4.1
Linseed Meal	0.34	0.42	0.94	.019	15.	.64	47.	----
Prairie Hay, Mostly Bluestem	0.32	0.30	0.15	.012	25.	.17	53.	1.0
Prairie Hay, Collected in Winter	0.47	0.26	0.07	.040	97.	.38	71.	0.6

From this, it would appear that if cattle were fed a ration containing the feeds listed in the previous table, their trace mineral requirements as proposed by Maynard (1951) for copper, manganese and cobalt would be met. Recent tests at Kansas (Smith et al., 1953) have shown no beneficial effects from adding a trace mineral mixture to beef cattle rations.

Thus, it would appear as suggested by Maynard (1951) that trace minerals should be added to the ration only when a deficiency in the soil and plant are indicated, rather than wide-spread use in areas where forages may contain ample amounts. The results obtained thus far from the addition of trace minerals to wintering rations for beef cattle have not consistently proven to be advantageous. It would seem that further work, similar to that of Glendening and associates (1952), is necessary in order to establish the need for trace minerals in beef cattle rations above the amounts commonly present in the grain and roughage normally consumed.

Methods of Processing Cottonseed As They Affect the Nutritive Value of the Oil Meal

Research at the Southern Regional Laboratory (1951) has shown that the nutritive value of cottonseed meal is affected by the method used in processing the cottonseed. In the hydraulic method of processing, the meals are cooked to a temperature of about 240° F and then pressed to extract the oil at a pressure of from 2,000 pounds to 4,000 pounds per square inch. In the screw-press method, the meals are cooked to a temperature of about 230° F then forced through the screw-press where the temperature often reaches 300° F. The pressure in the screw-presses may

be 10 to 12 tons per square inch. The pre-press solvent-extracted meals are processed in the same manner as the hydraulic meal, with the exception that when an oil level of about 10 percent is reached, a fat solvent (ether, for example) is added to remove as much oil as possible. Complete solvent extraction is accomplished by applying the solvent directly to the flakes. The meal is then toasted. Both water miscible and hydrocarbon solvents are used in the extraction of the oil.

Savage and McIlvain (1937-50) found that the solvent-extracted cottonseed meal produced equally as good gains when fed to steers wintering on dry, native range as the hydraulic-processed meals.

Marion et al., (1950), in their study of solvent-extracted vs. hydraulic-processed cottonseed meals, found no statistically significant difference in gains made by the steers fed either of the two meals. The fattening ration consisted of 4 pounds of cottonseed meal per steer daily plus sorghum grain, alfalfa hay, sorghum silage and sorghum fodder.

Riggs and Colby (1950) studied the value of hydraulic-processed and pre-press solvent-extracted cottonseed meals for wintering beef cows. They noted a difference in the weaning weights of the calves in favor of the hydraulic-processed meals, but were unable to explain this difference. In this study the effect of a lower fat content on the absorption of carotene, the blood levels of carotene, vitamin A and fat were found to be insignificant.

Marion and Jones (1951) have summarized the results of three trials in which cattle were fed hydraulic-processed and pre-press solvent-extracted

cottonseed meal in fattening rations. They obtained an increase of 0.08 pounds in average daily gain from the steers fed the hydraulic meal, but this difference was not significant.

Bennett (1950), in metabolism studies using 8 crossbred wether lambs, showed a significantly higher digestion coefficient for ether extract in favor of the pressure-processed meal at a maintenance level. The rations consisted of chopped prairie hay and various protein supplements. He found that the different methods of processing cottonseed meal had no significant effect on the apparent digestion coefficients for crude fiber, organic matter, or nitrogen free extract and concluded that cottonseed meals processed by different methods were of approximately equal value when used in maintenance and fattening rations for lambs.

Read (1952) found a statistically significant difference in the maintenance of body weight by ewes from 17 weeks before lambing to 42 days after lambing in favor of hydraulic-processed cottonseed meal. Lamb gains from birth to 42 days likewise favored the lot fed hydraulic meal; this difference was also statistically significant. The composition of the hydraulic and pre-press solvent-extracted meals used in this study were:

	Dry Matter	Ash	Crude Protein	Ether Ext.	Crude Fiber	N.F.E.
	%	%	%	%	%	%
Hydraulic-Processed	93.47	6.74	42.86	7.32	12.44	30.64
Pre-Press Solvent-Extracted	91.78	6.30	44.91	0.69	13.42	34.68

Gallup and co-workers (1950), in metabolism studies with hydraulic-processed and pre-press solvent-extracted cottonseed meals, found no significant difference in the nitrogen retention of steers or lambs fed the different meals in either maintenance or fattening rations.

From the results of the work to date, it would appear that the methods used in processing cottonseed produce oil meals of different nutritive value when fed to simple stomached animals, yet such differences have not been consistently shown with ruminants. The possibility of a difference in the nutritive value of hydraulic-processed and pre-press solvent-extracted cottonseed meals when fed to cattle wintering on dry, native range warrants further study.

Using Salt As A Means of Regulating Cottonseed Meal Intake

Pistor (1950) conducted a number of experiments to determine the influence of a high salt intake on the physiology of ruminants and found that when toxic levels are reached the following symptoms are noted: anxiety, hypersensitivity to the touch, loss of coordination, increased rate and intensity of rumen contraction, gas formation in the rumen, progressive weakness and death without struggling. To study the effect of a high salt intake, a fistulated cow was kept off water and feed for 36 hours, whereupon 2 pounds of salt and 3 gallons of water were introducted directly into the rumen. They found that the blood levels of NaCl reached 642 mgm. percent in 8 hours. The condition of the cow was critical in 12 hours, and it was necessary to wash out the rumen after 24 hours to prevent death. This same experiment was repeated with a greater quantity of water administered. The blood level of NaCl reached

500 milligrams percent, but no symptoms of distress were observed.

Studies on the toxicity of a high salt intake by Heller (1933), and Riggs (1950,1953) have shown that high levels of salt can be tolerated with no adverse effects. Beef cows were fed 1.05 pounds of salt and 2.19 pounds of cottonseed meal per head daily for a 107-day trial under ideal conditions of feed and water supply with no ill effects. The high salt intake caused no abortions.

Savage and McIlvain (1951) at the Southern Great Plains Field station showed that the consumption of cottonseed meal by wintering cattle could be successfully controlled by self-feeding a mixture of approximately 1 part salt and 3 parts cottonseed meal. Using Hereford steers, they found no adverse affects on the gain, grade and conditions of the steers receiving the salt-meal mixture. The amount of salt necessary to maintain consumption of cottonseed meal at 2 pounds per head daily in these experiments was 0.75 pound of salt for every 2 pounds of meal for a 700 pound steer. For a 450 pound steer, it required five-eights of a pound of salt and for a 300 pound steer, one-half pound of salt to 2 pounds of meal.

Archer et al., (1952), studying the advisability of self-feeding a mixture of salt and cottonseed meal to pregnant beef cows wintering on dry, native grass, obtained a 10 pound greater weight loss per cow in the self-fed group in one trial. The average birth weight of calves in the hand-fed group was 76 pounds vs. 69 pounds in the salt-meal group. There were no significant differences in the plasma sodium, potassium and chloride levels of the cows or their calves, or in the chloride content of the milk. In metabolism studies with steers fed a ration of

prairie hay and cottonseed meal supplemented with 10 and 250 grams of NaCl, they found that large amounts of salt did not significantly affect the digestibility of any of the ration constituents.

Smith (1950), studying the factors that influence a higher salt requirement in beef cattle, showed that when steers were fed a succulent feed, such as silage, they consumed three times as much salt as steers which were fed alfalfa hay. The steers receiving alfalfa hay had an average consumption of 0.1 pounds of salt per head daily as compared to 0.31 pounds per head daily in the silage groups.

In summary, the use of salt to control the intake of cottonseed meal when self-fed to beef cattle wintering on the range has been successfully demonstrated. The cattle have shown no ill effects from the high levels of salt consumed when an ample supply of water was available. Further studies, however, are needed to determine the advisability of self-feeding such a mixture to stocker cattle from the standpoint of cost of winter gains and market value of the cattle.

The Nutritive Value of Various Species of Grass for Wintering Cattle

Stoddart and Smith (1943), in their studies on range management, have pointed out some of the advantages of so-called "short" grass over "tall" grass. The tall vegetation does not cure as well on the range as does the short grass. The tall grasses tend to lose nutrients at a much faster rate; therefore, the loss of phosphorus, protein, and plant sugars make the tall grasses of less nutritive value for wintering cattle. The short grasses are noted for their relatively high feeding value and are highly palatable to cattle.

Studies on the nutritive value of range forage by Tash (1941) indicate that a low protein content in the forage is associated with a low phosphorus content, and that a deficiency of one complicates the other.

Heretofore, it has not been possible to compare the relative value of species of tall and short grasses for wintering cattle under similar soil and climatic conditions in Oklahoma. Since the amount of supplemental feed required for wintering beef cattle, and its protein content, may vary greatly with the quality of the forage, it seems important to conduct practical wintering trials to obtain a measure of the effect of the various types of pasture on the weight gains of beef cattle.

EXPERIMENTAL

Objectives

An experiment was conducted with yearling and two-year-old steers at the Fort Reno Experiment Station during 1950-53 with the following objectives:

1. To compare cottonseed meal and soybean meal as protein supplements for wintering steers on dry, native grass.

2. To determine the relative value of cottonseed meal and soybean meal with the calcium and phosphorus contents of the two supplements equalized by the addition of ground limestone or bone meal.

3. To determine the advisability of adding a trace mineral mixture containing cobalt, copper, iron, manganese, and zinc to protein supplements for steers wintering on dry, native grass.

4. To study the nutritive value of a mixture of 1 part sesame meal and 2 parts soybean meal as compared to soybean meal alone, with the calcium and phosphorus contents of the two supplements equalized.

5. To compare corn gluten meal to cottonseed and soybean meals as a protein supplement for wintering steers on dry, native grass.

6. To determine the value of a mixture of equal parts of cottonseed, soybean, and linseed meals as compared to cottonseed or soybean meal, with the calcium and phosphorus contents equalized.

7. To compare the nutritive value of cottonseed meals processed by the new pre-press solvent-extraction method and the old pressure (hydraulic or screw-press) methods as supplements to dry, native grass for wintering steers.

8. To determine the advisability of self-feeding a mixture of salt and cottonseed meal to steers wintering on dry, native grass pastures as compared to hand-feeding the same amount of protein supplement.

9. To compare so-called "tall" and "short" grass pastures for wintering steers fed the same amount and kind of protein supplement.

Procedure

Three wintering trials of a practical nature were completed in this study. The average beginning date of the trials was November 9 and the average length of the wintering period was 131 days. The trials varied somewhat in length due to the nature of the winter seasons encountered. An attempt was made to terminate the experiment each year before considerable green feed appeared in the pastures. Ten pastures were selected at the Fort Reno Station which would provide ample grass for the steers. The pastures were grazed lightly during the previous summer. There were nine short grass pastures in which buffalo (Buchloe daclytoides), blue grama (Bouteloua gracilis) and side oats grama (Bouteloua curtipendula) were the predominating species. One pasture contained a mixture of tall grasses in which the dominant species were big bluestem (Andropogon frucatus), little bluestem (Andropogon scoparius), Indian (Sorghastrum mutans), and switch grass (Ponicum virgatum).

In the 1950-51 trial, two hundred, two-year-old Hereford steers were purchased from a large ranch in Osage County and were divided into ten uniform lots of 20 head each. In the 1951-52 trial, one hundred and ninety-eight yearling Hereford steers were obtained from a ranch near Salina, Kansas, and were divided into eight lots of 20 head each and

two lots of 19 head each. In the 1952-53 trial, one hundred and eighty two-year-old Hereford steers which had been used in the same experiment the previous winter as yearlings were divided into ten uniform lots of 18 head each. The steers were divided into 10 groups each year on the basis of weight and grade, and the experimental treatments were imposed at random. A total of three trials were completed in which the steers were fed the following protein and mineral supplements per head daily:

Lot 1 - 2.17 pounds of cottonseed meal.

Lot 2 - 2.17 pounds of cottonseed meal plus 19.2 grams of ground limestone.

Lot 3 - Same as fed Lot 2, plus 0.86 grams of a trace mineral mixture*.

Lot 4 - 2.06 pounds of soybean meal.

Lot 5 - 2.06 pounds of soybean meal plus 18.6 grams of steamed bone meal.

Lot 6 - Same as fed Lot 5, plus 0.86 grams of a trace mineral mixture.

Lot 9 - 2.17 pounds of cottonseed meal self-fed in a salt mixture.

Lot 10 - 2.17 pounds of cottonseed meal on a tall grass pasture.

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* A commercially prepared trace mineral mixture fed at the rate of 0.86 grams per steer daily supplied approximately 2.83 mgm. of cobalt, 62.64 mgm. of manganese, 2.04 mgm. of zinc, 6.64 mgm. of copper, and 126.7 mgm. of iron.

The protein and mineral supplements fed steers of Lot 7 and 8 varied somewhat during the experiment. The treatments imposed, by years, were as follows:

In 1950-51:

Lot 7 - A mixture of 2 parts soybean meal and 1 part sesame meal plus ground limestone was fed in amounts to equal the protein, calcium and phosphorus intakes of steers of Lot 5.

Lot 8 - Same as fed Lot 7 plus a trace mineral mixture.

In 1951-52:

Lot 7 - Corn gluten meal in protein equivalent amounts to the cottonseed meal and soybean meal fed Lots 1 and 4, respectively.

Lot 8 - Pre-press solvent-extracted cottonseed meal in amounts to equal the hydraulic-processed cottonseed meal fed Lot 1.

In 1952-53:

Lot 7 - A mixture of equal parts of cottonseed, soybean and linseed meals, plus ground limestone and bone meal, in amounts equal to the protein, calcium and phosphorus contents of the supplements fed Lots 2 and 5.

Lot 8 - Pre-press solvent-extracted cottonseed meal.

The amount of protein supplement fed each lot was adjusted to provide the same protein intake among the lots. The supplements were fed in bunks beneath large open sheds. The minerals fed lots 2, 3, 5, 6, 7, and 8 were sprinkled on top of the protein supplement during the first

two trials and mixed with the protein supplement in a large vertical mixer during the last trial. The protein and mineral supplements were fed every other day, twice the daily allowance at each feeding, as is a common practice on the range. The salt-cottonseed meal mixture fed lot 9 was adjusted as required to maintain a protein intake about equal to that hand-fed lot 1. The steers grazing short grass pastures (with the exception of those in lots 1 and 4 during the first trial) were rotated among the pastures at frequent intervals to equalize pasture differences. Salt was available free-choice to the steers of all lots.

The initial and final weights were taken after an overnight shrink without access to water. The steers were driven in from the pasture during the late afternoon and kept in dry lot until the weights were taken the following morning. At the completion of each trial, the steers were appraised by two representatives of the Oklahoma City livestock market. The data were treated statistically by the analysis of variance according to Snedecor (1946).

RESULTS AND DISCUSSION

The results obtained in yearly trials are given in appendix Tables 9 (1950-51), 11 (1951-52) and 13 (1952-53) with the corresponding feed and grass analyses in Tables 10, 12 and 14. Wherever possible, the results of the three trials have been averaged together in the following discussion, while the results of one or two trials are presented separately.

Cottonseed Meal vs. Soybean Meal for Wintering Steers on Native Grass

A summary of the results of three trials (1950-53) in which cottonseed and soybean meals were compared as protein supplements for wintering steers on native grass are shown in Table 1, with average chemical composition of feeds and grasses in Table 2. The statistical analysis of the data and orthogonal comparisons made are shown in Tables 3 and 4.

The steers of Lot 1 grazing dry, native grass and supplemented with 2.17 pounds of cottonseed meal per head daily lost an average of 7 pounds per steer, while steers of Lot 4 fed soybean meal on a protein equivalent basis gained an average of 25 pounds per steer. When the weight gains of the steers were subjected to an analysis of variance as shown in Table 3, soybean meal was superior to cottonseed meal at the one percent level of significance. Ross and associates (1950), in similar studies with two-year-old steers, found that steers fed soybean meal as a protein supplement to dry, native grass made significantly more winter gains than those fed cottonseed meal. Average winter gains in this study were 3 pounds per head for steers fed cottonseed meal, as compared to 43 pounds per head for steers fed soybean meal. From the results of their studies, it was suggested that quality of protein

Table 1.

Summary of Results Obtained in a Study of Protein and Mineral Supplements, Cottonseed Meal-Salt Mixtures, and Tall vs. Short Grass Pastures for Wintering Steers[1] at the Fort Reno Station. (Average of 3 Trials, 1950-53, 131 Days)

	Lot 1 Cottonseed Meal	Lot 2 Cottonseed Meal+Lime-stone	Lot 3 Cottonseed Meal+Lime-stone+Tr. Min.	Lot 4 Soybean Meal	Lot 5 Soybean Meal+ Bone Meal	Lot 6 Soybean Meal+Bone Meal+Tr. Min.	Lot 9 Cotton-seed Meal+Salt Self-fed	Lot 10 Cotton-seed Meal (Tall Grass)
Steers per lot	58	58	57[3]	57[3]	58	58	57	57
Average weights (lbs.)								
Initial weight	889	889	889	889	889	889	889	889
Final weight	882	910	904	914	905	908	880	831
Total gain or loss	-7	21	15	25	16	19	-9	-58
Supplemental feeds(lbs./day except as indicated)[2]								
Cottonseed meal	2.17	2.17	2.17				2.28	2.17
Soybean meal				2.06	2.06	2.06		
Ground limestone (gms.)		19.2	19.2					
Bone meal (gms.)					18.57	18.57		
Trace minerals (gms.)			.86			.86		
Salt	.04	.04	.04	.04	.04	.04	.72	.04
Winter feed cost per steer (dollars)								
Protein supplement	12.33	12.33	12.33	12.01	12.01	12.01	12.89	12.34
Ground limestone		.04	.04					
Bone meal					.27	.27		
Trace mineral			.02			.02		
Pasture	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08
Salt	.04	.04	.04	.04	.04	.04	.65	.04
Total cost (dollars)	17.45	17.49	17.51	17.13	17.40	17.42	18.63	17.46

(Table 1. continued on next page)

Table 1. (continued)

	Lot 1 Cottonseed Meal	Lot 2 Cottonseed Meal+Lime-stone	Lot 3 Cottonseed Meal+Lime-stone+Tr. Min.	Lot 4 Soybean Meal	Lot 5 Soybean Meal+ Bone Meal	Lot 6 Soybean Meal+Bone Meal+Tr. Min.	Lot 9 Cottonseed Meal+Salt Self-fed	Lot 10 Cotton-seed Meal (Tall Grass)
Financial Results (dollars)								
Initial cost @ $28.17 per cwt.	250.43	250.43	250.43	250.43	250.43	250.43	250.43	250.43
Appraised value per cwt.	28.08	28.08	28.08	28.08	28.08	28.25	27.92	28.17
Total value per steer	247.66	255.53	253.84	256.65	254.12	256.51	240.95	234.09
Return per steer	-20.22	-12.39	-14.46	-10.91	-13.71	-11.34	-28.11	-33.98

[1]Age of steers were: 1950-51, two-year-olds; 1951-52, yearlings; and 1952-53, two-year-olds.
[2]Values represent the average amount fed for three years.
[3]One steer removed from each lot and are not included in these data.

Table 2

Chemical Composition of Feeds and Grasses
(Average of 3 Years, 1950-53)

	Percent dry matter	Percentage Composition of Dry Matter					
		Ash	Protein	Fat	Crude Fiber	N-Free Extract	Calcium	Phosphorus
Hydraulic process								
Cottonseed meal	92.65	6.95	44.01	6.30	11.00	31.71	.22	1.10[3]
Soybean meal	91.80	6.75	49.34	2.83	7.92	33.16	.44	.77
Ground limestone		99.14					38.00	
Bone meal		86.74					32.00	14.8
Pasture grass								
October								
Tall grass[1]		8.17	3.53	1.87	31.75	52.61	.42	.061
Short grass[2]		9.74	6.84	1.79	28.97	52.66	.34	.092
November								
Tall grass		7.53	2.52	1.66	39.29	48.99	.30	.051
Short grass		10.10	4.76	1.89	32.60	51.21	.34	.075
December								
Tall grass		5.95	1.97	1.96	38.81	43.35	.26	.028
Short grass		8.92	4.98	1.62	32.62	50.28	.32	.079
January								
Tall grass		5.73	2.09	1.80	39.80	50.60	.22	.049
Short grass		10.12	4.16	1.14	32.13	51.86	.32	.066
February								
Tall grass		7.81	2.33	1.70	37.27	49.28	.30	.032
Short grass		9.83	3.86	1.56	31.63	49.36	.31	.066

[1] Average by species, big and little bluestem and Indian grass.

[2] Average by species, side oats and blue grama, buffalo grass.

[3] Phosphorus content of cottonseed meal used in this average for 1952-53 was 0.856 per cent. Later analysis showed the phosphorus content to be 1.19 per cent.

might be of considerable importance for ruminants. However no attempt was made in their studies to compensate for the difference in calcium and phosphorus contents of the two meals.

Table 3

Analysis of Variance and Orthogonal Comparisons of Weight Gains of Steers in Lots 1, 4, 9 and 10.[a]

Source of Variation	D.F.	Sum of Squares	Mean Squares
Total	228	473,639	
Treatment	3	197,708	65,903**
Lots 1, 4, 9 vs. 10	1	157,528	157,528**
Lots 1, 9 vs. 4	1	39,856	39,856**
Lots 1 vs 9	1	324	324
Error	217	204,012	940

**Probability of chance occurrence less than .01

[a]The lot means were as follows: Lot 1, -6.72; Lot 4, 23.94; Lot 9, -10.08; Lot 10, -58.33.

When the calcium and phosphorus contents of the two oil meals were equalized by the addition of ground limestone to cottonseed meal (Lot 2) and bone meal to soybean meal (Lot 5), the winter gains of the steers were 21 pounds and 19 pounds per head, respectively. This difference in winter gain between Lots 2 and 5 was not significant. Further examination of the weight gains of the steers, as shown in Table 1, reveals that the performance of Lot 2 steers receiving cottonseed meal to which additional calcium had been added was principally responsible for failure to show a difference between the two meals since the addition of bone meal to soybean meal gave no improvement (compare Lots 1 vs. 2 and Lots 4 vs. 5). The extra gain obtained from the addition of ground limestone to the cottonseed meal fed steers of Lot 2 resulted in an average winter gain of 21 pounds per head, as compared to an average loss of 7 pounds per head for steers of Lot 1 which received no mineral supplement other than salt. This advantage obtained from adding ground limestone to cottonseed meal was consistent

each year in this study and a non-orthogonal statistical comparison revealed it to be significant at the 5 per cent level.

The additional gains made by steers fed cottonseed meal supplemented with ground limestone on dry native grass is of particular interest. Research on the effect of adding calcium to cottonseed meal in rations containing large amounts of roughage is limited. It is commonly accepted that roughages grown on soils not deficient in calcium will contain an ample supply of this mineral to meet the needs of cattle, providing sufficient quantities are fed (Morrison, 1950). The calcium content of grass samples taken during the three-year study would indicate that the steers were meeting their calcium requirement from the grass consumed, if a normal consumption of roughage is assumed. However, Maynard (1951) has pointed out that the availability of calcium in forage may vary considerably according to the chemical combination present and its physical association with other compounds. Further studies are needed to clarify this point and to determine the means by which additional calcium is beneficial.

When bone meal was added to the soybean meal fed steers of Lot 5, their average winter gain was 19 pounds per head, while steers of Lot 4 fed soybean meal alone gained an average of 25 pounds per head. There was no advantage from adding bone meal to soybean meal in this study. Ross and associates (1950) obtained an increase in the weight gains of two-year-old steers wintering on tall native grass by the addition of bone meal to soybean cake. However, the higher phosphorus content of the short grasses in this study as compared to the tall grass pastures used in the experiments of Ross and associates may have been largely responsible for the failure to obtain a similar response. The phosphorus

supplied by the soybean meal fed steers of Lot 4, together with that present in grass, appeared to be ample for wintering steers in this study.

The average appraised value of the steers at the completion of the trials for Lots 1, 2, 4 and 5 was $28.08 per hundredweight. The average cost of protein and mineral supplements fed was $12.29 per head, with a range of only $12.05 to $12.37 per head. Due to the severe drop in cattle prices during the last two years of this study, all lots lost money. The extent of financial loss was related to the gain or loss in body weight of the steers during the winter period, since there were only small differences in the cost of protein supplement and no difference in appraised value at the end of the trial.

The Effect of Adding Trace Minerals to Cottonseed and Soybean Meals

A trace mineral mixture was added to the protein supplements fed steers in Lots 3 and 6 and their performance compared with steers of Lots 2 and 5. The calcium and phosphorus contents of the protein supplements fed were equalized by the addition of ground limestone or bone meal. The average results obtained are shown in Table 1, with the composition of feeds and grasses in Table 2. The difference in gain or loss of body weight by steers in Lots 3 and 6 was not significantly different from the performance of steers in Lots 2 and 5, as indicated by the analysis of variance shown in Table 4.

In this study, which includes six comparisons of protein supplements with and without trace minerals, in only one instance was there an increase in the winter gains of steers on dry, native grass pastures from the addition of the trace minerals. Commercial feed manufacturers have recommended the widespread use of trace minerals in protein and mineral sup-

Table 4

Analysis of Variance of Weight Gains of Steers in Lots 2, 3, 5, and 6[a]

Source of variation	D.F.	Sum of squares	Mean squares
Total	231	206,157	
Treatment	3	1,558	519
Error	220	176,286	801.3

[a]The lot means were as follows: Lot 2, 21.64; Lot 3, 15.78; Lot 5, 15.60; Lot 6, 18.9

plements for beef cattle. However, Maynard (1951) has reviewed the literature on the importance of trace minerals and found that only cobalt, copper and iodine have been shown to be deficient in the United States and that these deficiencies appear in rather limited areas. The work of Glendening et al., (1952) on the chemical composition of the feeds common to central Kansas is an important step in determining the need for the addition of trace minerals to rations containing natural feedstuffs.

Nelson et al. (1951), and Totusek and associates (1953), in their experiments in southeastern Oklahoma where the phosphorus and manganese levels of the native grass have been shown to be abnormal, have been unable to show a consistent benefit from adding trace minerals to beef cattle rations. It has been shown that the forage produced in that area of the state is low in phosphorus and high in manganese. Studies on the effect of a high manganese intake on calcium and phosphorus metabolism are now underway at the Oklahoma station.

Further work is needed, similar to that of Glendening and associates at Kansas, before complete trace mineral mixtures can be recommended for state-wide use, particularly in view of the extreme variation in species of grass and soil types from one area to another.

Self-feeding a Cottonseed Meal and Salt Mixture

The results of a three-year study in which steers of Lot 1 were hand-fed cottonseed meal and those of Lot 9 were self-fed a mixture of salt and cottonseed meal are given in Table 1. The chemical composition of the protein supplement and grass samples are given in Table 2. The steers which were hand-fed cottonseed meal (Lot 1) lost and average of 7 pounds per head during the winter test, while steers self-fed a mixture of cottonseed meal and ground rock salt (Lot 9) lost an average of 9 pounds per head. This difference in loss of body weight between Lots 1 and 9 was not significant (see Table 3). The overnight shrink of the steers of the two lots prior to obtaining the final weights was determined each year. The results are not given here, but in general show little difference between the lots under the weather conditions encountered. The winter seasons encountered during this three-year study would be classified as relatively mild and therefore favorable for steers receiving high intakes of salt. The steers consumed an average of 0.72 pound of salt per head daily during the winter periods which increased the total cost of supplemental feed by $1.18 per steer. It was necessary to change the ratio of salt to meal frequently in order to maintain a protein intake equal to that fed Lot 1.

The average appraised value of steers hand-fed cottonseed meal (Lot 1) was $28.08 per hundredweight as compared to $27.92 per hundredweight for those self-fed the salt and meal mixture (Lot 9).

Studies by Savage (1951), Cox (1951, and Riggs (1953) on the advisability of self-feeding a salt-cottonseed meal mixture to cattle have

given results similar to those obtained in this experiment. It is felt that where such a system of self-feeding is to be followed, good management practices with close observation of the herd are essential.

Tall vs. Short Grass Pastures for Wintering Steers

A three-year study (1950-53) was conducted in which comparable groups of steers grazed tall and short grass pastures and were fed equal amounts of cottonseed meal. The results of this study are given in Table 1, with the chemical composition of the cottonseed meal and grass samples shown in Table 2. No mineral other than salt free-choice was given the steers.

The steers grazing tall grass pastures (Lot 10) in which the predominant grass species were big and little bluestem, Indian and switch, lost an average of 58 pounds per head during the winter, while those grazing short grass pastures (Lot 1), in which blue grama, buffalo and side oats gramas predominated, lost 7 pounds per head. Thus, the steers on short grass pastures were 51 pounds per steer heavier at the end of the winter period than steers grazing tall grass pastures. This difference was statistically significant, as shown in Table 3.

It is generally accepted that the so-called short grasses are superior to tall grasses for wintering cattle, and such an advantage was borne out in this study. The chemical composition of the grass samples as shown in Table 2 reveals that short grasses were higher in protein and phosphorus than tall grasses from November to February, under similar climatic conditions. Therefore, greater amounts of supplemental feeds containing protein and phosphorus are needed to produce a desired rate of gain when cattle are wintered on tall grass pastures as compared to those wintered on short grass.

The financial returns for steers in Lots 1 and 10 were directly related to the loss in weight during the winter, since the appraised value at the end of the trial and the cost of protein supplement was essentially the same.

Soybean Meal vs. a Soybean-Sesame Meal Mixture for Wintering Steers on Native Grass

The results of one trial (1950-51) in which a mixture of one part sesame and two parts soybean meal (Lot 7) was compared to soybean meal (Lot 5), with the protein, calcium and phosphorus contents of the two supplements equalized are shown in Table 5. The chemical composition of the supplements and grass samples are shown in Table 10, appendix. The same supplements were compared with trace minerals added to each one (Lots 6 and 8). The average winter gains of two-year-old steers fed soybean meal (Lots 5 and 6) were 14.5 pounds per head greater than those fed the soybean-sesame mixture (Lots 7 and 8). A soybean-sesame meal mixture has been shown to contain a protein of higher biological value than soybean meal for chicks (Almquist 1944), yet such an advantage was not apparent in these trials with steers wintering on dry, native grass. However, small differences in nutritive value as are likely to exist between two such supplements would be difficult to measure with nearly mature steers wintering on the range.

The average appraised value of steers in Lots 7 and 8 was $33.08 per hundredweight, as compared to $33.00 per hundredweight for steers in Lots 5 and 6 fed the soybean meal. It was apparent at the completion of the trial that the steers in Lot 8 showed more bloom and condition of the hair coat than steers of any other lot.

Table 5
Soybean Meal vs. a Soybean-Sesame Meal Mixture, and the Two Supplements with Trace Minerals Added, for Wintering Steers on Dry Native Grass (One Trial, 1950-51, 134 Days)

	Lot 5 Soybean Meal+Bone Meal	Lot 7 Soybean Meal+Sesame Meal+ Limestone	Lot 6 Soybean Meal + Bone Meal + Tr. Min.	Lot 8 Soybean Meal + Sesame Meal + Gr. Limestone + Tr. Mineral
Steers per lot	20	20	20	20
Average weight (lbs.)				
Initial weight	948	948	948	948
Final weight	944	936	978	957
Total gain or loss	-4	-12	30	9
Supplemental feeds, (lbs. per day except as indicated)				
Soybean meal	3.0	2.0	3.0	2.0
Sesame meal		1.0		1.0
Ground limestone (gms)		7.2		7.2
Bone meal (gms)	6.8		6.8	
Trace mineral (gms)			.80	.80
Salt	.04	.04	.04	.04
Winter feed cost per steer (dollars)				
Protein supplement	15.08	15.08	15.08	15.08
Ground limestone		.02		.02
Bone meal	.08		.08	
Trace mineral			.02	.02
Pasture	5.00	5.00	5.00	5.00
Salt	.04	.04	.04	.04
Total cost (dollars)	20.20	20.14	20.22	20.16
Financial results (dollars)				
Initial cost at $28.00/cwt.	265.44	265.44	265.44	265.44
Appraised value per cwt.	32.75	32.50	33.25	33.75
Total value per steer	309.16	304.20	325.18	322.98
Return per steer (market value less cost of steer and feed)	23.52	18.61	39.52	37.38

Corn Gluten Meal vs. Soybean and Cottonseed Meals for Wintering Steers

A further trial was conducted during the winter of 1951-52 to compare corn gluten meal with cottonseed and soybean meals as protein supplements to dry, native grass for wintering yearling steers. Corn gluten meal was used in this study because it is recognized to be of poor quality for swine and chickens. The results obtained are shown in Table 6, with feed analysis given in Table 12, appendix. The steers of Lot 7 fed corn gluten meal gained 36 pounds per head during the winter, while those of Lot 1 fed cottonseed meal and steers of Lot 4 fed soybean meal gained 13 pounds and 53 pounds per head, respectively. The results of this trial suggest that corn gluten meal is about equal in value to cottonseed meal and soybean meal for wintering steers on dry, native grass. Kansas workers (1941) reported satisfactory gains when corn gluten meal was used as the protein supplement to a winter ration of sorghum silage for yearling steers.

Corn gluten meal is not a common protein supplement in this area and thus the feed cost of wintering steers of Lot 7 was approximately $2.00 more per head than for Lots 1 or 4 fed cottonseed or soybean meals. The appraised value of the steers in Lots 1 and 7 were the same, with Lot 4 steers fed the soybean meal appraised at $0.50 per hundredweight higher.

A Mixture of Protein Supplements vs. Cottonseed and Soybean Meals for Wintering Steers

Many commercial protein supplements contain a mixture of linseed, cottonseed and soybean meals. Commercial feed manufacturers have claimed that such a mixture provides a better balance of amino acids and is therefore superior to protein from a single source for wintering cattle. A single trial was conducted (1952-53) in which a mixture of equal parts of linseed,

Table 6

Corn Gluten Meal vs. Cottonseed and Soybean Meals for Wintering Steers on Dry Native Grass (One Trial 1951--1952, 135 Days)

	Lot 1 Cottonseed Meal	Lot 4 Soybean Meal	Lot 7 Corn Gluten Meal
Number of steers per lot	20	20	20
Average weight (lbs.)			
Initial weight	665	665	665
Final Weight	678	718	701
Total gain or loss	13	53	36
Supplemental feeds (lbs./day)			
Cottonseed meal	1.51		
Soybean meal		1.40	
Corn gluten meal			1.41
Salt	.04	.04	.04
Winter feed cost per steer(dollars)			
Protein supplement	8.15	8.69	10.28
Pasture	4.00	4.00	4.00
Salt	.04	.04	.04
Total cost (dollars)	12.19	12.73	14.32
Financial results (dollars)			
Initial cost @ $33.00/cwt.	219.45	219.45	219.45
Appraised value per cwt.	32.50	33.00	32.50
Total value per steer	220.35	236.94	227.82
Return per steer (market value less steer cost and feed)	-11.29	4.76	-5.95

cottonseed, and soybean meals was compared to either cottonseed meal or soybean meal. The results are given in Table 7, with the chemical analyses of the feeds and grass samples shown in Table 14, appendix.

Table 7

Comparison of Cottonseed Meal, Soybean Meal, and a Mixture of Cottonseed, Soybean and Linseed Meals for Wintering Steers on Dry Native Grass. (One Trial, 1952-53, 125 Days.)

	Lot 2 Cottonseed Meal+Ground Limestone	Lot 5 Soybean Meal+ Bone Meal	Lot 7 Cottonseed Meal +Soybean Meal + Linseed Meal + Bone Meal + Limestone
No of steers per lot	18	18	18
Average weight (lbs.)			
Initial	1054	1053	1054
Final	1065	1079	1051
Total gain or loss	11	26	-3
Supplemental feeds (lbs./day except as indicated)			
Cottonseed meal	2.0		.66
Soybean meal		1.78	.66
Linseed oil meal			.66
Ground limestond (gms.)	15.43		8.17
Bone meal (gms.)		15.89	5.45
Salt	.05	.05	.05
Winter feed cost per steer (dollars)			
Protein supplement	13.25	12.26	13.77
Ground limestone	.04		.02
Bone meal		.25	.08
Pasture	6.25	6.25	6.25
Salt	.04	.04	.04
Total cost (dollars)	19.58	18.80	20.16
Financial results (dollars)			
Initial cost @ $23.50/cwt.	247.69	247.45	247.69
Appraised value per cwt.	19.00	19.00	19.00
Total value per steer	267.27	266.25	199.69
Return per steer (market value less cost of feed and steer)	-64.91	-61.24	-68.16

Steers of Lot 7 fed a mixture of the three protein supplements lost an average of 3 pounds per head during the winter test, while those of Lots 2 and 5 fed cottonseed and soybean meals gained 11 and 26 pounds per head, respectively. Any advantage for a mixture of protein supplements over a single supplement was not demonstrated in this study. The cost of the mixture of proteins was greater than the cost of either cottonseed or soybean meal alone, with no advantage in rate of gain or appraised value of the steers. This is in agreement with previous work which has failed to show a beneficial value of a mixture of supplements over a protein supplement from a single source for wintering cattle.

Solvent-Extracted vs. Hydraulic-Processed Cottonseed Meals for Wintering Steers on Native Grass.

The average results obtained, supplements fed and returns per steer for two trials (1951-52, 1952-53) in which pre-press solvent-extracted cottonseed meal was compared to hydraulic-processed cottonseed meal as protein supplements to dry, native grass pastures for wintering steers are given in Table 8, with the chemical composition of feed and grass samples shown in Table 14, appendix. The steers of Lot 1 fed the hydraulic-processed cottonseed meal lost an average of 4 pounds per head during the two-year study, while steers of Lot 8 fed solvent-extracted cottonseed meal maintained their body weight. In this two year study, the results favored the steers fed solvent meal in one trial and hydraulic meal in the other. Thus, it appears that little difference exists in the nutritive value of hydraulic-processed or pre-press solvent-extracted cottonseed meal for wintering steers on dry, native grass. An examination of the chemical composition of the two meals reveals a difference in fat content of 5.65 per cent in favor of the hydraulic-processed meal. The lower fat content

of the solvent-extracted meal did not appear to affect the performance of the steers under the rather mild climatic conditions encountered in this study. The average appraised value of the steers at the end of the trial was the same for the two lots.

The results of this study are in agreement with those reported by Marion (1951), Riggs (1950), and Savage (1937-50), in that the method of processing cottonseed meal has little effect on its nutritive value when fed to steers wintering on the range. However, Read (1952), working with sheep, and Riggs (1950) working with cows, have shown an advantage for hydraulic-processed cottonseed meal in rations for lactating females. Also, fattening tests with steers have rather consistently shown an advantage for hydraulic-processed meal. It would seem that under greater stress than maintenance of body weight, or where maximum performance is desired, a difference in the nutritive value of the two meals may exist.

Table 8.

Hydraulic-Processed vs. Pre-press Solvent-Extracted Cottonseed Meals for Steers Wintering on Dry Native Grass (Average of Two Trials, 1951-52 and 1952-53, 130 Days).

	Lot 1 Hydraulic--Processed Cottonseed Meal	Lot 8 Solvent--Process Cottonseed Meal
Number of steers per lot	38	38
Average weight (lbs.)		
Initial weight	859	859
Final weight	855	859
Total gain or loss	-4	0
Supplemental feeds (lbs./per day except as indicated)		
Cottonseed meal(hydraulic process)	1.75	
Solvent cottonseed meal		1.67
Salt	.04	.04
Winter feed cost per steer (dollars)		
Protein Supplement	10.70	10.18
Pasture	5.12	5.12
Total cost (dollars)	15.86	15.34
Financial results (dollars)		
Initial cost @ $28.25 per cwt.	242.67	242.67
Appraised value per cwt.	25.75	25.75
Total value	220.16	221.19
Return per steer (Market value less cost of steer and feed).	-38.27	-36.82

SUMMARY

Three winter trials involving a total of 578 yearling and two-year-old Hereford steers were conducted at the Ft. Reno station during 1950-53 in a study of the comparative value of various protein and mineral supplements to dry, native grass pastures. Also included in these trials were a comparison of the relative value of different grass species for wintering steers, and the advisability of self-feeding a salt-cottonseed meal mixture to steers wintering on the range.

The results of this three-year study showed soybean meal to be significantly superior ($P = < .01$) to cottonseed meal when no mineral supplement other than salt was fed. Then calcium (ground limestone) was added to cottonseed meal and phosphorus (bone meal) to soybean meal to equalize the calcium and phosphorus contents of the two supplements, winter gains of the steers were not significantly different. The study revealed that steers receiving cottonseed meal plus ground limestone made greater gains than those fed the meal without calcium supplementation. The addition of bone meal to soybean meal was of no advantage in this study with steers grazing short grass pastures.

In three wintering trials, the addition of a trace mineral mixture to cottonseed or soybean meals supplemented with calcium and/or phosphorus failed to increase the weight gains of steers wintering on dry, native grass.

The results obtained with self-feeding a mixture of cottonseed meal and salt to steers wintering on dry, native grass showed this practice to be feasible, although feed costs were greater than for steers hand-fed the same amount of cottonseed meal.

Short grasses were significantly superior ($P = < .01$) to tall grasses for wintering steers fed the same amount of protein supplement under the conditions of this study.

Steers fed a mixture of 1 part sesame meal and 2 parts soybean meal made less winter gains than those fed soybean meal. Corn gluten meal was found to be of about equal value to cottonseed or soybean meals for wintering yearling and two-year-old steers on dry, native grass.

A mixture of equal parts of cottonseed, soybean and linseed meals did not prove to be superior to either cottonseed or soybean meal in this study.

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APPENDIX

Table 9. Results of the 1950-51 Study of Protein and Mineral Supplements For Wintering Two-Year-Old Steers on Native Grass (135 Days).

Lot Number	1	2	3	4	5	6	7	8	9	10
Supplements	C.S. Meal	C.S. Meal + Lime-stone	S.B.M. -Lime+ stone+ Tr.Min.	S.B. Meal	S.B. Meal+ -Bone Meal	S.B. Meal + Bone Meal + Tr.Min.	S.B. Meal+ Sesame Meal +Lime-stone	S.B.M.+ +Ses-ame M. +lime-stone+ Tr.Min.	C.S.M. +Salt Self-fed	C.S. Meal (Tall Grass)
Steers per lot	20	20	19[1]	20	20	20	20	20	20	20
Average weights (lbs.)										
Initial 11-6-51	948	948	948	948	948	948	948	948	948	948
Final 3/21/52	935	975	972	947	944	978	936	957	928	896
Total gain or loss	-13	27	24	-1	-4	30	-12	9	-20	-52
Av. daily gain or loss	-.10	.20	.18	-.01	-.03	.22	-.09	.07	-.15	-.39
Supplemental feed (lbs./day except as indicated										
Cottonseed meal(Hydraulic)	3.0	3.0	3.0						3.0	3.0
Soybean meal				3.0	3.0	3.0	2.0	2.0		
Sesame meal							1.0	1.0		
Ground limestone (gms.)		12.6	13.3				7.2	7.2		
Bone meal (gms.)					6.8	6.8				
Trace mineral (gms.)			8.4			.80		.80		
Salt	.04	.04	.04	.04	.04	.04	.04	.04	.95	.04
Winter feed cost (dollars/steer)										
Protein Supplement	15.58	15.58	15.58	15.08	15.08	15.08	15.08	15.08	17.60	15.58
Ground limestone		.03	.03				.02	.02		
Bone meal					.08	.08				
Trace mineral			.02			.02		.02		
Pasture	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Salt	.04	.04	.04	.04	.04	.04	.04	.04	.86	.04
Total	20.62	20.65	20.67	20.12	20.20	20.22	20.14	20.16	23.46	20.62

(Table 9 - Continued on next page)

Table 9 (Continued)

Lot Number	1	2	3	4	5	6	7	8	9	10
Returns per steer(dollars)										
Initial cost at $28.00 per cwt.	265.44	265.44	265.44	265.44	265.44	265.44	265.44	265.44	265.44	265.44
Appraised price per cwt.	32.75	32.75	32.75	32.25	32.75	33.25	32.50	33.75	32.75	32.50
Market value	306.21	319.21	318.33	305.41	309.16	325.16	304.20	322.98	303.92	291.20
Return per steer (Market value less steer and feed cost)	20.15	33.22	32.22	19.85	23.52	39.52	18.61	37.38	15.02	5.14

[1]One steer removed November 17 due to eye trouble.

Table 10 - Feed and Grass Analyses. 1950-51

	Percent dry matter	Percentage Composition of Dry Matter						
		Ash	Protein	Fat	Crude Fiber	N-Free Extract	Cal-cium	Phos-phorus
Cottonseed meal	93.87	6.82	44.16	7.74	11.09	30.16	.21	1.10
Soybean oil meal	93.03	7.19	48.79	3.05	9.05	31.93	.52	1.01
Sesame meal	93.91	7.08	49.01	7.42	6.39	30.11	.22	1.35
Bone meal		86.74					32.40	14.00
Ground limestone		99.14					38.30	
Grasses:								
November								
Tall grass[1]		6.61	2.30	1.68	40.58	48.81	.254	.073
Short grass[2]		9.92	4.78	1.92	33.51	50.97	.360	.098
December								
Tall grass		5.14	2.02	1.54	42.46	46.91	.192	.024
Short grass		5.46	5.22	1.52	35.98	47.04	.332	.108
January								
Tall grass		5.73	2.09	1.80	39.80	50.60	.221	.049
Short grass		10.12	4.16	1.14	32.13	51.86	.321	.066
February								
Tall grass		8.55	2.03	1.40	37.81	50.19	.261	.029
Short grass		8.21	4.30	1.50	32.90	53.09	.300	.050

[1]Average by species; big bluestem, little bluestem, and Indian grass.
[2]Average by species; buffalo grass side oats and blue grama.

Table 11. Results of the 1951-52 Study of Protein and Mineral Supplements for Wintering Yearling Steers on Native Grass (135 Days).

Lot Number	1	2	3	4	5	6	7	8	9	10
Supplements	C.S. Meal	C.S.M. + Ground Lime-Stone	C.S.M. + Ground Lime-stone + Tr.Min.	S.B. Meal	S.B.M. + Bone meal	S.B.M. + Bone Meal + Tr.Min.	Corn Gluten Meal	Solvent C.S. Meal	Salt + C.S.M. Self-fed	C.S.M. (Tall Grass)
Steers per lot	20	20	20	20	20	20	20	20	19	19
Average weight (lbs.)										
Initial 11-6-51	665	665	665	665	665	666	665	665	665	665
Final 3-21-52	678	690	690	718	691	682	701	690	683	595
Total gain or loss	13	25	25	53	26	16	36	25	18	-70
Av. daily gain or loss	.10	.19	.19	.39	.19	.12	.27	.19	.13	-.52
Supplemental feed (lbs./day except as indicated)										
Cottonseed meal(Hydraulic)	1.51	1.51	1.51						1.51	1.50
Cottonseed meal(Solvent)								1.45		
Soybean meal				1.40	1.40	1.40	1.41*			
Ground limestone (gms.)		29.7	29.7							
Bone meal (gms.)					32.9	32.9				
Trace minerals		.65				.65				
Salt	.04	.04	.04	.04	.04	.04	.04	.04	.38	.04
Winter feed cost (dollars per steer)										
Protein supplement	8.15	8.15	8.15	8.69	8.69	8.69	10.28	7.83	7.83	8.20
Ground limestone		.07	.07							
Bone meal					.47	.47				
Trace minerals			.01			.01				
Pasture	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Salt	.04	.04	.04	.04	.04	.04	.04	.04	.38	.04
Total	12.19	12.26	12.27	12.73	13.20	13.21	14.32	11.87	12.21	12.24

(Table 11. Continued on next page)

Table 11. (Continued)

Lot Number	1	2	3	4	5	6	7	8	9	10
Returns per steer (dollars)										
Initial cost at $33.00 per cwt.	219.45	219.45	219.45	219.45	219.45	219.78	219.45	219.45	219.45	219.45
Appraised price/cwt.	32.50	32.50	32.50	33.00	32.50	32.50	32.50	32.50	32.00	33.00
Market value	220.35	224.25	224.25	236.94	224.57	221.65	227.82	224.25	218.56	196.35
Returns per steer (Market value less cost of steer and feed)	-11.29	-7.46	-7.47	4.76	-8.08	-11.34	-5.95	-7.07	-13.10	-35.34

*This lot received Corn Gluten Meal.

Table 12 - Feed and Grass Analyses. 1951-52

	Percent dry matter	Percentage Composition of Dry Matter						
		Ash	Protein	Fat	Crude Fiber	N-Free Extract	Calcium	Phosphorus
Hydraulic Process								
Cottonseed meal	91.55	7.46	44.34	6.44	10.64	31.12	.20	1.35
Solvent Process								
Cottonseed meal	90.97	6.19	47.32	.59	12.72	33.18	.25	1.08
Soybean meal	91.78	6.04	49.27	4.83	6.74	33.12	.45	.66
Corn gluten meal	91.34	2.43	48.74	1.16	3.33	44.34	.12	.35
Bone meal		86.74					32.00	14.00
Ground limestone		99.14					38.00	
Pasture grass:								
November								
Tall grass[1]		8.46	2.73	1.64	38.00	49.17	.35	.03
Short grass[2]		10.19	4.74	1.83	31.70	51.51	.32	.06
December								
Tall grass		6.66	2.29	1.99	39.37	49.69	.37	.03
Short grass		11.15	4.55	1.58	31.18	51.54	.35	.07
February								
Tall grass		7.82	2.79	1.79	38.81	48.79	.36	.04
Short grass		11.79	4.95	1.40	31.22	50.65	.37	.08

[1]Average by species, big and little bluestem and Indian grass.
[2]Average by species, side oats grama and buffalo grass.

Table 13. Results of the 1952-52 Study of Protein and Mineral Supplements for Wintering Two-Year-Old Steers on Native Grass (125 Days).

Lot Number	1	2	3	4	5	6	7	8	9	10
Supplements	C.S. Meal	C.S. Meal + Lime.	C.S.M. + Lime-stone + Tr. Min.	S.B. Meal	S.B.M. + Bone Meal	S.B. Meal + Bone Meal + Tr.Min.	S.B.M. + C.S.M. + Linseed M. + Lime. + Bone M.	Solvent C.S.M.	Salt + C.S.M. Self-fed	C.S.M. (Tall Grass)
Steers per lot	18	18	18	18*	18	18	18	18	18	18
Average weights (lbs.)										
Initial 11-5-52	1053	1054	1054	1059	1053	1055	1054	1054	1054	1053
Final 3-10-53	1032	1065	1051	1076	1079	1063	1051	1029	1028	1002
Total gain or loss	-21	11	- 3	17	26	8	- 3	-25	-26	-51
Ave. daily gain or loss	-.17	.09	-.02	.14	.21	.06	-.02	-.20	-.21	-.41
Supplemental feed (lbs/day except as indicated)										
Cottonseed meal (Hydraulic)	2.0	2.0	2.0			.	.66		2.0	2.0
Cottonseed meal (Solvent)							→	1.88		
Soybean meal				1.78	1.78	1.78	.66			
Linseed meal							.66			
Ground limestone (gms.)	15.4	15.4					8.2			
Bone meal (gms.)					15.9	15.9				
Trace minerals (gms.)		1.1				1.1				
Salt	.05	.05	.05	.05	.05	.05	.05	.05	.83	.05
Winter feed cost (dollars per steer)										
Protein supplement	13.25	13.25	13.25	12.26	12.26	12.26	13.77	12.46	13.25	13.25
Ground limestone		.03	.03				.02			
Bone meal					.25	.25	.08			
Trace minerals		.02				.02				
Pasture	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25
Salt	.04	.04	.04	.04	.04	.04	.04	.04	.73	.04
Total	19.54	19.57	19.59	18.55	18.80	18.82	20.16	18.75	20.23	19.54

(Table 13. Continued on next page)

Table 13. (Continued)

Lot Number	1	2	3	4	5	6	7	8	9	10
Financial data (dollars)										
Initial cost at $23.50 per cwt.	247.45	247.69	247.69	248.86	247.54	247.92	247.69	247.69	247.69	247.45
Appraised value/cwt.	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00
Market value	196.08	202.35	199.69	204.44	205.01	201.97	199.69	195.51	195.32	190.38
Return per steer (Market value less feed and steer costs)	-70.91	-64.91	-67.59	-61.80	-61.24	-64.77	-68.16	-70.93	-72.60	-76.61

*One steer removed due to a digestive disorder and is not included in these data.

Table 14 - Chemical Composition of Feeds and Grasses, 1952-53.

	Percent dry matter	Percentage Composition of Dry Matter						
		Ash	Protein	Fat	Crude Fiber	N-Free Extract	Calcium	Phosphorus
Hydraulic Process								
Cottonseed meal	92.53	6.58	43.54	4.73	11.29	33.86	.25	.856[3]
Solvent Process								
Cottonseed meal	91.75	6.76	46.32	.92	12.86	33.14	.21	.873
Soybean meal	90.61	7.01	49.96	.61	7.97	34.45	.34	.651
Linseed meal	93.00	6.82	38.36	3.93	10.89	40.00	.47	.701
Ground limestone		99.14					38.00	
Bone meal		86.74					32.00	16.00
Grasses:								
October								
Tall grass[1]		8.17	3.53	1.87	31.75	52.61	.42	.061
Short grass[2]		9.74	6.84	1.79	28.97	52.66	.34	.092
December								
Tall grass		6.06	1.60	2.36	35.96	53.47	.21	.030
Short grass		10.15	5.17	1.77	30.10	52.80	.29	.059
February								
Tall grass		7.07	2.18	1.92	35.19	48.57	.28	.027
Short grass		9.50	2.33	1.80	30.17	44.36	.25	.068

[1]Average by species, big and little bluestem and Indian grass.
[2]Average by species, side oats and blue grama, buffalo grass.
[3]An additional sample of cottonseed meal was obtained after the completion of the trial and chemical analysis revealed that the phosphorus content was 1.19 per cent. The value shown in the above table, however, was used during the trial.

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