PROTEIN SUPPLEMENTS FOR FALL-CALVING BEEF COWS

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INTRODUCTION

The importance of adequate protein in the wintering ration of beef cows has been emphasized in the last quarter-century by numerous studies conducted in those areas of the country where the quality of the native forage decreases during the winter months, and where the cows are allowed to graze such forage yearlong without an additional supply of roughage. Much research has been devoted to determining the kind and amount of protein supplement that will best meet the protein requirements of mature beef cows during the winter months.

This research, together with periodic shortages of protein supplements, has resulted in an increased use of urea in wintering rations as well as supplements that contain less than 40 percent protein. There have been many studies which indicate that urea may satisfactorily replace part of the protein in the rations of fattening cattle. However, there is a lesser number of tests relating to the value of high levels of urea in wintering rations fed as a supplement to limited quantities of dry native pasture grass.

From previous studies with protein supplements with less than 40 percent protein, it has been concluded that such supplements are not as efficient as 40 percent protein supplements in promoting weight gains during a single winter feeding period. Thus, it seemed desirable to study the accumulative effects of feeding for several successive winters protein supplements containing 40 percent protein, those containing less than 40 percent protein, and a supplement containing a large percentage (50%) of the nitrogen as urea, to wintering beef cattle under range conditions.

REVIEW OF LITERATURE

Information included in this review concerns the value of different supplements at various levels of wintering for optimum performance of beef cattle during growth, reproduction, and lactation.

Protein Supplements for Wintering Beef Cattle

Lantow and Snell (1924) reported that calves from cows which had received additional supplement during the winter were heavier at birth than calves from non-supplemented cows. A higher percentage of calves was also reported from the supplemented cows. These workers also reported that very little difference resulted from feeding ground corn, cottonseed cake, or a mixture of the two, when fed over a 126-day period to cows being wintered on the range. The 4 cows fed 2.84 lb. of cottonseed cake gained an average of 8 lb. and the 5 cows fed the same amount of corn lost an average of 6 lb. during the feeding period.

Using a different group of heifer calves each year, Lantow (1930) conducted a study over a three-year period in which each group of heifers was permitted to graze the native range forage the entire yearly period. During the winter, some of the heifer calves were fed different amounts of cottonseed cake in addition to grazing the native forage, with the remainder of the heifers receiving no additional feed. Results of this investigation showed that as the amount of supplement fed was increased, the average winter gains also increased. Heavier average yearly gains were reported for the supplemented heifers than for the non-supplemented heifers, with little difference resulting among groups which received approximately the same amount of cottonseed

cake during the winter. The heifers fed the higher levels of supplement made greater yearly gains than those fed the lower levels.

Reporting the results of a five-year study which involved approximately 550 head of cows, Black, Quesenberry, and Baker (1938) showed that average yearly weights of supplemented and unsupplemented cows were almost equal. Calves from cows fed cottonseed cake were, on the average, 1.9 lb. heavier at birth and 13.6 lb. heavier at weaning time than calves from cows receiving no supplement. Feed cost was such that it usually made the practice of supplementation unprofitable, except in the case of severe climatic conditions.

A series of five experiments were conducted by Stanley (1938) to compare the relative merits of wintering range cattle with and without the feeding of cottonseed cake. Supplementation was at an average rate of 1.0 to 1.5 lb. per head daily for approximately 114 days each winter season. The results indicate that the average final weights of cows receiving cottonseed cake to be 35 lb. heavier than those of cows receiving no cake. Calves from cows that were fed the cake during the winter were significantly heavier at birth than calves produced by cows fed no supplementary protein. The average weaning weight of the calves from the cake-fed cows was slightly greater than that of calves from the cows receiving no cake but the difference was not great enough to pay for the supplementary cottonseed cake.

Connel et al. (1948) reported the results of a three-year study in which they tested the effect of adding a protein supplement to the wintering ration for steer calves. All the calves received chopped forage sorghum fodder and silage ad libitum as the basal ration. One group was fed 1.0 lb. per head daily of either cottonseed meal or

soybean oil meal in addition to their roughage ration, while the other group received no type of protein supplementation. The feeding of protein supplement resulted in an increase in average daily gain during the winter from 0.49 to 1.24 lb.

Brouse (1944) found that calves wintered on prairie hay with no additional supplement made little or no gain. Thus, a study was undertaken to determine the value of cottonseed cake as a protein supplement to prairie hay for wintering calves. This investigation revealed that feeding of 0.5, 0.75, or 1.0 lb. of cottonseed cake during the wintering period resulted in increased winter and yearly gains. A comparison was also made concerning the relative value of 1.0 and 1.5 lb. of cottonseed cake as a supplement for calves being wintered on prairie hay ad libitum. Results of this comparison indicated that supplementing prairie hay daily with 1.5 lb. of cottonseed cake per head produced greater average winter gains. However, the average yearly gains of the calves fed 1.0 and 1.5 lb cottonseed cake during the winter were about equal.

Kessler, Aicher, and Weber (1950) summarized the results of a three-year study of the effect of supplementing silage with 0.5 or 1.0 lb. cottonseed cake on the winter gains of stock calves. Calves receiving 1.0 lb. of cottonseed cake showed a greater average daily gain than those receiving 0.5 lb. supplement. The average daily gain was 0.74 and 0.56 lb. for 1.0 and 0.5 lb. of supplemental cottonseed cake, respectively. The average feed cost was less per 100 lb. of gain for the calves fed cottonseed cake at the rate of 1.0 lb. per day than for those fed 0.5 lb. per day.

Using weanling calves, Brouse (1944) conducted a trial to compare the relative value of 12 percent protein cubes and cottonseed cake as supplements to prairie hay during the wintering period and grass during the grazing period. One group of calves was fed the 12 percent protein supplement and another group was fed cottonseed cake during the winter. Both groups were fed their respective supplement at the rate of 0.75 lb. per head daily during the wintering period and 1.0 lb. per head daily during the subsequent grazing period. The average winter gains of weanling calves under this nutritional regime were 140 and 111 lb. for cottonseed cake and 12 percent protein cubes, respectively. Both groups of calves made equal summer gains of 256 lb. per head.

This same worker conducted a subsequent study in which he compared the relative value of 1.0 lb. of cottonseed cake, 22 percent protein cubes, and 12 percent protein cubes for supplementing prairie hay fed ad libitum to weanling calves during the winter and allowed to graze native grasses during the summer. The average winter gains of the calves fed cottonseed cake, 22 percent protein cubes, and 12 percent protein cubes were 186, 142, and 115 lb. per head, respectively. The average yearly gains were in the same order.

Foster, Biswell, and Hostetler (1945) conducted three wintering trials with lactating beef cows to determine the relative effects of different levels of protein supplement. Cottonseed meal was fed as the protein supplement in the first and third trials, with soybean oil meal serving this purpose in the second trial. These supplements were fed at levels of 2.0, 4.0, and 6.0 lb. in the second and third trials. The same cows were used in each trial to study the accumulative effects of feeding protein supplements at different levels. The weight changes

of nursing cows during the wintering period in all three trials were in proportion to the amount of supplement fed. The lots receiving the most supplement in all cases either lost less weight or gained more. On the average, gains during the grazing season were inversely related to weight changes during the winter. Calf gains in the wintering period were nearly 50 percent greater in the group where cows received 6.0 lb. of soybean or cottonseed meal per head daily than those in the 2.0- or 4.0-lb. lots. When the total winter and summer gains of the calves were considered, those in the 6.0-lb. lot made the greatest gains, and those in the 2.0-lb. lot made the lowest gains.

Fontenot (1954) reported the results of a four-year study to test the relative value of supplements of different protein content for weanling beef heifer calves fed prairie hay ad libitum or allowed to graze dry native grass during the winter. Results of this study reveal that when supplements containing 20-, 30-, and 40-percent protein were fed in the same amounts under the same experimental conditions, the average winter gains of the heifer calves were positively related, and average summer gains were negatively related, to the protein level of the supplement. The average yearly gains of the heifers wintered in traps and fed prairie hay ad libitum increased with increases in the protein content of the supplement fed during the winter. The average yearly gains of heifers allowed to graze dry native grass during the winter were slightly greater for those fed 1.0 lb. per head per day of the 20-percent protein supplement than for those fed an equal amount of the 40-percent protein supplement. When the two supplements were fed at the rate of 2.0 lb. per head per day to heifers wintered on dry range grass, the yearly gains were slightly in favor of the cattle fed

the 40-percent protein supplement.

Reporting the results of a three-year study designed to compare two levels of supplemental winter feeding for beef cows suckling calves, Nelson et al. (1958) revealed that the average difference in winter gains of cows fed the two levels of supplement (1.5 lb. pelleted cottonseed meal vs. 2.5 lb. pelleted cottonseed meal plus 3 lb. corn or milo) was only 39 lb. (271 lb. vs. 232 lb.). The average birth weight of calves was apparently unaffected by the nutritional regime imposed upon the cows, nor could any significance be placed upon the small differences in calving date.

Bohman and Torell (1956) reported that weanling cattle fed either alfalfa or cottonseed meal as protein supplements gained significantly faster during the winter period than non-supplemented animals fed native grass hay. The observed differences in rate of gain between the animals fed cottonseed meal and alfalfa were not statistically significant. However, during the summer, alfalfa appeared to have a residual effect and promoted gains exceeding those of cottonseed meal. With the exception of the alfalfa treatments, there was less difference in total gains between the control animals and the supplemented cattle at the end of the summer grazing season than at the end of the wintering period.

Johnson, Moxon, and Smith (1952) wintered bred beef cows on South Dakota ranges and found that 8.0 to 10.0 lb. of good quality roughage fed daily excelled 1.0 lb. of a 40-percent protein concentrate. Should the 8.0 to 10.0 lb. of roughage be of poor quality (5.5 to 6.5 percent protein), the feeding of 1.0 lb. of cottonseed meal excelled the low-quality roughage for cattle grazing native grass pastures. Also included in the results of this test was the finding that 1.0 lb. of a

40-percent protein soybean cube fed daily to cows on winter pastures, plus bone meal and salt always produced heavier cows in the spring and calves that had a higher average weaning weight than feeding 1.0 lb. of 24-percent protein soybean-corn cubes.

Most of the available data on the use of complex supplements are related to the value of such supplements in rations for fattening cattle rather than for wintering. However, data are available relating to the value of the individual ingredients of the complex supplement used in this study. For example: Nelson et al. (1956) concluded that trace minerals were of no apparent benefit when the rations of range beef cattle provided an adequate amount of roughage, protein, phosphorus, and salt. Burkitt et al. (1954) reported that pregnant beef cows could be wintered quite satisfactorily on 2.0 lb. of linseed meal as the only supplement to low-quality roughages. Nelson and co-workers (1957) reported that the average of four wintering trials with calves showed a slight advantage in weight gains from the inclusion of dehydrated alfalfa meal or molasses in a pellet to be fed as a supplement to weathered prairie hay.

In a review of non-protein nitrogen utilization, Reid (1953) concluded that urea utilization is favored by a low level of true protein and a high level of starch in the ration. Highly soluble and readily hydrolyzable proteins were observed to have a depressing effect on the utilization of urea nitrogen, since most bacteria within the rumen preferred true protein nitrogen. Since urea is soluble in water and rapidly hydrolyzed, the need for available carbohydrates to furnish energy for ruminal microorganisms at the time of ingestion is made known. Sugars and cellulose can serve as sources of energy, but in

most cases they have proven to be inferior to starch as sources of energy for ruminal microorganisms. Sugars have been found to disappear from the rumen at such a rate that their energy isn't efficiently utilized by bacteria while the energy from cellulose is released so slowly that it is of little value in satisfying the energy requirement of bacteria.

Dinning and associates (1949) fed to steers and lambs pellets in which urea supplied 25 to 50 percent of the total nitrogen and found that nitrogen retention was increased by the additional nitrogen supplied by urea. The 50 percent urea-nitrogen supplement was as efficient as the 25 percent supplement in promoting retention. However, feed refusals were noted when the 50 percent supplement was fed in wintering rations. Feeding the 25 percent urea-nitrogen supplement at less frequent intervals, on alternate days as compared to daily and twice daily, had no effect on urea utilization by steers. In this study, lambs were found to be more efficient than the steers in utilizing urea nitrogen; however, the steers were more efficient than lambs in the digestion of most ration constituents, especially crude fiber.

Reynold et al. (1956) conducted two winter feeding trials to compare the value of cottonseed meal, cottonseed meal and urea, and a supplement composed of 2.25 lb. of soybean meal, 1.0 lb. of molasses feed, minerals and vitamins A and D, when fed with corn silage and grass hay or with hay alone. The protein supplements were pelleted and fed at the rate of 1.0 lb. per head per day to all lots. Urea was added to certain supplements at the rate of 7 percent. In each trial, approximately one-half of the lots were fed all the corn silage they would consume plus a limited amount of hay, while the remaining lots

received all the hay they would consume. Results indicated that there were no significant differences among lots fed the same roughage; however, the corn silage-hay lots made significantly better gains than the hay lots in each trial. Urea was found, on the average, to be effective in replacing part of the cottonseed meal in these supplements.

Gallup and co-workers (1953) used 210 calves during an 8-year period to determine the value of urea as an extender of protein in fattening rations. The pelleted feeds used in most of the feeding trials were made up of different proportions of cottonseed meal, hominy feed, and urea, plus 10.0 percent blackstrap molasses. The pellets were generally of three types as regards to the total nitrogen supplied by urea: 25 percent, 50 percent, and 75 percent. In all three types, the combination of urea with other protein was adjusted so that the pellets contained the equivalent of 42 to 45 percent crude protein. A pellet having 85 percent of the nitrogen furnished by urea was used in two fattening trials with steers.

Results of the feeding trials comparing urea supplements with cottonseed cake for fattening calves indicate that pelleted feed mixtures containing 25 and 50 percent of their crude protein as urea were as satisfactory as cottonseed cake from the standpoint of feed efficiency, rate of gain, and total gain produced. However, the urea-fed cattle sold at a slightly lower price than those fed cottonseed meal.

In contrast, when 85-percent urea-nitrogen pellets were fed and compared to cottonseed cake, gains were reduced by 0.32 lb. per steer daily, and the concentrates necessary to produce 100 lb. of gain were increased by 67 lb. The 85-percent urea-nitrogen pellets were found to be slightly unpalatable, thereby limiting their use.

The value of urea as a protein substitute for wintering steers and heifers was also studied. For three successive years, yearling heifers were divided into two groups and wintered on dry native grass and protein supplements for 100 to 148 days. The heifers in one group were fed a supplement composed of cottonseed meal and those in a corresponding group were fed a pelleted supplement with 25 percent of its nitrogen as urea. The two supplements, which contained equal amounts of protein, were fed at a rate of approximately 2.45 lb. per head daily. In a similar comparison, two-year-old steers were wintered on dry native grass and approximately 3.0 lb. cottonseed cake or urea pellets in three successive years. Results of these wintering trials revealed that heifers or steers fed the 25-percent urea pellets wintered as well as those fed an equal amount of cottonseed meal.

Reporting the results of four feeding trials conducted over a 3-year period, Greeley (1957) found that the addition of trace minerals to urea-containing pellets increased the utilization of urea by beef calves and yearlings during winter grazing on dried native grass. Dehydrated alfalfa meal was also effective in promoting increased urea utilization when added to protein pellets containing urea as one-third of its nitrogen. This author also reported the results of two winter feeding trials conducted over a 2-year period which involved the feeding of protein supplements, in which urea supplied approximately one-third of the total nitrogen, with and without trace minerals as a supplement to prairie hay for 89 beef calves. Results indicated that little, if any, improvement in urea utilization was obtained by the addition of trace minerals to the urea-containing supplement.

Supplementing a low-protein roughage with protein produces an

increase in winter gains of cattle. Increasing the protein intake up to a certain level by increasing the total amount of a high-protein supplement or by increasing the concentration of protein in a supplement produces an increased winter gain in calves and cows. Protein supplementation of the dam's ration apparently has an effect on the weaning weight of the offspring, but does not seem to have a marked effect on the birth weight of the young under experimental conditions.

EXPERIMENTAL OBJECTIVES

The data reported in this thesis are the results of a four-year study with the following objectives:

1. To determine the relative value of supplements containing 20- and 40-percent crude protein when fed for several successive winters to commercial beef cattle grazing native grass.
2. To compare a 20-percent protein supplement composed of corn and cottonseed meal to one composed of several feed ingredients for wintering commercial cattle grazing native pasture.
3. To determine the value of a feed supplement containing approximately fifty percent of the total nitrogen as urea for wintering commercial beef cattle grazing native grass.

EXPERIMENTAL PROCEDURE

One hundred grade Hereford heifer calves were divided into 5 lots of 20 head each on November 2, 1953. Each of these lots was placed in a pasture which provided approximately 5 acres of native grass per heifer. In addition to the dried grass at the Lake Carl Blackwell experimental range area, the heifers were fed a protein supplement during the winter months as follows:

Lot 1. 1 lb. of 40-percent protein pelleted cottonseed meal.

Lot 2. 2 lb. of 40-percent protein pelleted cottonseed meal.

Lot 3. 2 lb. of 20-percent combination pellet.

Lot 4. 2 lb. of 20-percent pellet (CSM and corn).

Lot 5. 2 lb. of 40-percent pellet containing urea.*

The 40-percent protein pellet contained 97.99 percent cottonseed meal and 2.01 percent dicalcium phosphate.

The 20-percent protein combination pellet consisted of several different feed ingredients. Included were several different sources of protein, dehydrated alfalfa meal, molasses and minerals which furnished nutrients that might add to the value of a simple mixture of corn and cottonseed meal. The percentages of the various ingredients in this 20-percent protein combination pellet were: cottonseed meal, 12.5; linseed oil meal, 12.5; soybean oil meal, 12.5; dehydrated alfalfa meal, 5.0; yellow corn, 41.7; molasses, 10.0; monosodium phosphate, 3.7; ground limestone, 1.0; salt, 1.0; and trace mineral mixture, 0.1.

The simple 20-percent protein pellet was composed of 37 percent

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*A commercial product Urea 262 supplied through the courtesy of E. I. DuPont de Nemours and Co., Wilmington, Delaware.

cottonseed meal, 58.84 percent yellow corn, 2.36 percent dicalcium phosphate, and 1.80 percent monosodium phosphate.

The 40-percent protein pellet containing urea was the same as the simple 20-percent protein pellet except that 7.64 percent of the corn was replaced with urea in order to make the nitrogen content of the pellet equivalent to 40 percent protein (N x 6.25).

The calcium and phosphorus contents of all pellets were equalized by the addition of ground limestone, dicalcium phosphate, and monosodium phosphate. The average chemical composition of the pellets fed in the four winter periods is reported in Table I.

At all times except during the summer of 1955, a mixture of 2 parts salt and 1 part steamed bone meal was available in all lots. During the summer of 1955 the only mineral supplement available was salt because the heifers were used in a test to determine the value of a salt and phenothiazine mixture in the control of cattle grubs.

The pellets were fed, in the kinds and amounts as listed, to the same cattle as heifer calves during the winter of 1953-54 and as yearling heifers during the winter of 1954-55. At the beginning of the winter feeding period for 1955-56, the allowance of supplemental feed was increased to 1.5 lb. per head daily in Lot 1 and 3 lb. per head daily in the other lots. Thus, as two- and as three-year-olds, the same cattle were continued on their respective rations as in the two previous winters with only the amount of each supplement fed being changed. Twice the daily allowance of supplement was fed every other day in all tests.

All cattle grazed the native grass pastures yearlong. After the first two years the acres of native grass available per head were

TABLE I

Chemical Composition of Feeds

Feed	Year	Percent dry matter	Percentage Composition of Dry Matter						
			Ash	Protein	Fat	Fiber	NFE	Ca	P
40-CSM	1953-54	92.03	10.32	40.68	5.01	10.01	33.98	1.76	1.45
	1954-55	90.42	8.02	43.64	5.78	11.86	30.70	0.82	1.25
	1955-56	91.95	7.41	39.50	6.28	10.18	36.63	0.54	1.47
	1956-57	92.29	8.89	43.81	3.69	13.78	29.83	0.73	1.19
20-Comb.	1953-54	88.21	12.86	22.40	3.36	5.03	56.35	2.09	1.48
	1954-55	88.51	9.93	24.11	3.80	5.86	56.30	0.75	1.21
	1955-56	91.03	8.20	21.20	4.66	4.90	51.99	0.50	1.59
	1956-57	91.21	10.38	24.33	3.07	6.01	56.21	0.85	1.55
20-CSM + corn	1953-54	89.64	4.69	22.04	4.83	4.77	63.67	0.94	1.44
	1954-55	89.26	7.55	22.12	3.41	6.54	60.38	0.90	1.24
	1955-56	91.43	6.52	21.02	5.64	4.78	62.04	0.60	1.46
	1956-57	90.98	7.92	24.80	4.74	6.45	56.09	0.77	1.41
40-Urea	1953-54	88.81	7.99	41.84	5.66	4.93	39.58	1.61	1.34
	1954-55	89.06	7.56	43.76	3.93	5.36	39.39	0.92	1.22
	1955-56	91.55	6.45	41.34	6.04	5.16	41.01	0.71	1.48
	1956-57	89.52	6.69	46.70	4.02	6.37	36.22	0.73	1.33

increased from 5 to approximately 8 acres per head. The yearling heifers were bred so as to drop their first calf in the fall of 1955 when they were approximately two and one-half years old. Thus, the nutrient requirements during the third and fourth trials were for reproduction and lactation as well as maintenance and growth. Because of these increased requirements the experiment was believed to be a critical test of the value of the various supplements. Individual photographs were taken of every animal in this study each year soon after the beginning of the winter feeding period.

The cost of the various pellets was calculated from the cost of the individual feed ingredients plus a mixing and pelleting charge of five dollars per ton. On this basis, the cost per ton for the various protein supplements for the four different tests was that as given in Table II. It should be noted that with the exception of the 1954-55 wintering period when the price of cottonseed meal was higher than usual, the combination pellet has been the most expensive pellet fed in this test.

TABLE II

Cost of Pellets

(Dollars per Ton)

Year	Lot 1 40-CSM	Lot 2 40-CSM	Lot 3 20-Comb	Lot 4 20-CSM + Corn	Lot 5 40-Urea
1953-54	70.00	70.00	75.38	68.06	73.88
1954-55	83.32	83.32	80.28	75.84	81.14
1955-56	69.66	69.66	73.95	68.26	72.54
1956-57	72.50	72.50	76.36	72.49	76.16

RESULTS AND DISCUSSION

Trial 1, Calves in 1953-54

A summary of the average production and cost data is given in Table III. The calves in Lot 2 gained an average of 15 lb. during the wintering period. Average weight losses ranging from 1.0 lb. in Lot 3 to 14 lb. in Lot 5 resulted from feeding the various protein supplements in the other lots. Statistical analysis of these weight changes indicates that the weight gains of the calves in Lot 2 are significantly different ($P < 0.01$) from those of the other four lots. Table IV presents the design of statistical analysis used to analyze the data for this trial. A comparison of the gains in Lot 2 with gains in the other lots would indicate that protein was a factor limiting gains. The calves in Lots 1, 3 and 4 were fed pellets furnishing equal protein but a considerable difference in amounts of other nutrients. The average weight losses for these three lots during the wintering period were 2, 1, and 12 lb. for Lots 1, 3, and 4, respectively, indicating that the other nutrients furnished by the pellets fed in Lots 3 and 4 were not the factors limiting gains. The differences in weight losses occurring in Lots 1, 3 and 4 were not statistically significant. One lb. of a 40-percent protein pellet was apparently just as satisfactory as 2.0 lb. of 20-percent protein pellets. The 20-percent protein pellet containing corn and cottonseed meal (Lot 4) was of slightly less value than the 20-percent protein combination pellet, but the difference was not statistically significant. The greatest loss (14 lb.) occurred when a 40-percent protein pellet containing urea (Lot 5) was fed. This weight loss was not significantly different from the losses of -2, -1,

TABLE III

Weight Gains and Feed Cost of Heifer Calves, 1953-54

	Lot 1 40-CSM	Lot 2 40-CSM	Lot 3 20-Comb	Lot 4 20-CSM+Corn	Lot 5 40-Urea
Number of head per lot[1]	20	20	20	17	20
Average weight (lb.)					
Initial 11-2-53	485	478	479	481	479
Spring 4-13-54	483	493	478	469	465
Winter gain	-2	+15	-1	-12	-14
Fall 10-30-54	681	685	683	674	668
Summer gain	198	192	205	205	203
Yearly gain	196	207	204	193	189
Cost of protein supplement ($)	4.32	8.64	11.45	10.35	11.23

1. Originally there were 20 heifers per lot. In Lot 4, 2 heifers calved in the spring of 1954 and 1 heifer died in March, 1954.

TABLE IV

Design of Statistical Analysis for Trial 1

Source of Variation	d.f.	Mean Square	F
Total	96		
Treatment	4	10,466	4.87
2 vs. 1, 3, 4 and 5	1	7,564	14.11
5 vs. 1, 3 and 4	1	1,488	2.78
1 vs. 3 and 4	1	320	
3 vs. 4	1	1,074	2.00
Within	92	536	

and -12 lb. in Lots 1, 3 and 4, respectively. The supplements fed in Lots 1, 3 and 4 furnished only half as much protein on a protein equivalent basis as the urea-containing pellet fed to the calves of Lot 5. Apparently little, if any, of the urea was utilized in this test.

Trial 2, Yearlings in 1954-55

A summary of the average production and cost data is given in Table V. Comparison of the winter gains or losses resulting from the feeding of three different pellets that furnished equal protein reveals that feeding 1.0 lb. of 40-percent protein pellet (Lot 1) resulted in the greatest average gain. The average weight changes during the second wintering period were 7, -27 and -14 for Lots 1, 3 and 4, respectively. An equal amount of protein was fed in each of these lots. Those fed 2.0 lb. of 20-percent protein pellets lost weight while those fed 1.0 lb. of 40-percent protein pellet gained slightly. The feeding of the 40-percent protein pellet containing urea (Lot 5) was apparently equal to feeding the pellet containing an equal amount of protein as a natural feedstuff (Lot 2). There is no apparent explanation for greater gains resulting from the feeding of 1.0 lb. as compared to 2.0 lb. of 40-percent protein supplement. Statistical analysis of the weight changes occurring during the second trial reveal a significant ($P < 0.05$) difference in treatments. This significant difference was found to be due to the highly significant difference ($P < 0.01$) between Lot 1 and Lots 3 and 4. All of the other comparisons were found to be non-significant. The design used for analysis of the data from this trial may be found in Table IV. There is no readily apparent explanation for the winter weight changes. A possible explanation of these

TABLE V

Weight Gains and Feed Costs of Yearlings, 1954-55

	Lot 1 40-CSM	Lot 2 40-CSM	Lot 3 20-Comb	Lot 4 20-CSM+Corn	Lot 5 40-Urea
Number of head per lot[1]	19	16	19	16	20
Average weight (lb.)					
Fall 10-10-54	680	680	682	676	668
Spring 4-19-55	687	673	655	662	668
Winter gain	7	-7	-27	-14	0
Fall 10-10-55	980	949	942	942	944
Summer gain	299	276	287	280	276
Yearly gain	305	269	260	266	276
Cost of protein supplement ($)	6.54	12.83	12.37	11.71	12.46

1. In the previous trial, there were 20 heifers in each lot except Lot 4, which had 17. In the spring of 1955, 1 heifer in Lots 1, 3, and 4, and 4 heifers in Lot 2 calved.

changes may be related to the observation that after mid-February many green plants could be found in the pastures and such quantities of protein may have been available from these plants that gains were not related to protein supplement fed. There was no apparent difference in the amount of green material available in the different pastures.

Trial 3, Two-Year-Olds in 1955-56

A summary of the average production and cost data is presented in Table VI. During this season the amount of protein supplement fed during the winter was increased to 1.5 lb. per head daily in Lot 1

TABLE VI

Weight Gains and Feed Costs of Two-Year-Olds, 1955-56

	Lot 1 40-CSM	Lot 2 40-CSM	Lot 3 20-Comb	Lot 4 20-CSM+Corn	Lot 5 40-Urea
Number of head per lot[1]	16	15	15	11	15
Average weight (lb.)					
Fall 10-10-55	983	953	953	955	934
Spring 4-24-56	756	820	772	740	773
Winter gain	-227	-133	-181	-215	-161
Weaning 8-4-56	980	984	981	978	975
Gain from spring	224	164	209	238	202
Fall 9-26-56	1005	1015	1017	985	980
Summer gain	249	195	245	245	207
Yearly gain	22	62	64	30	46
Cost of protein supplement ($)	14.39	23.54	24.66	23.17	24.29

1. In trial II, there were 19, 16, 19, 16, and 20 cows in Lots 1, 2, 3, 4, and 5, respectively. In Lot 1, 3 cows were open. In Lot 2, 1 cow was open. In lot 3, 3 cows were open. In Lot 4, 3 cows were open, 1 calf born dead, and 1 cow died. In Lot 5, 2 cows were open and 3 calves were born dead or died between birth and weaning.

and 3.0 lb. per head daily in the other lots. Data are included for only those cows that weaned a calf during the summer of 1956.

All cows lost weight during the wintering period. Such weight losses would be expected because of losses due to calving and lactation during the winter months. Statistical analysis of the data from this trial indicated a highly significant difference ($P < 0.01$) in treatments. Although there was considerable variation in weight losses among lots,

with the least loss (133 lb.) in Lot 2, the difference between the loss in this lot and the remaining lots was not significant. The statistical design for analysis of the data from this trial is the same as used in the two previous trials and may be found in Table IV. A comparison of the weight losses in the two lots fed the 40-percent protein pelleted cottonseed meal reveals that the average weight loss of the cows in Lot 1 (1.5 lb. pellets) was considerably greater than in Lot 2 (3 lb. pellets). When urea was added to a supplement containing 20-percent protein in such amounts that the protein equivalent was raised to 40 percent, the weight loss per head was 54 lb. less than when the 20-percent protein supplement was fed. However, weight loss of the cows fed the urea-containing pellet was 28 lb. greater than when an equal amount of the 40-percent protein pellet was fed. Apparently some of the urea was utilized in this trial inasmuch as the weight losses of the cows fed the urea-containing pellet were intermediate between the losses of cows fed equal amounts of the 20- and 40-percent protein supplements. Statistical analysis reveals that the cows in Lot 5 (3 lb. 40-percent protein pellet containing urea) lost significantly less ($P < 0.01$) weight than the cows in Lots 1, 3 and 4. The average winter weight loss for Lots 1, 3 and 4 was 227, 181 and 215 lb. per head, respectively. The weight loss of the cows in Lot 1 was significantly greater ($P < 0.05$) than for the other two lots fed supplements that furnished equal protein (Lots 3 and 4).

The condition of the native grass pastures was considerably below normal during the unusually dry summer of 1956. Because of the decreased amount of forage available in the pastures, the stocking rate was increased to approximately 8 acres per cow.

Calf data for both the 1955-56 and 1956-57 seasons will be presented in another section.

Trial 4, Three-Year-Olds in 1956-57

A summary of the average production and cost data is reported in Table VII. All cows lost considerably more weight during this winter feeding period than during the previous winter. A highly significant difference ($P < 0.01$) was found among treatments when the data were statistically analyzed. The cows fed 3.0 lb. of the 40-percent protein supplement (Lot 2) lost the least (255 lb.) weight during the wintering period, with the weight losses in the other lots varying from 273 lb. in Lot 3 to 324 lb. in Lot 1. Statistical comparison of the losses of cows fed 3.0 lb. of the 40-percent protein pelleted cottonseed meal (Lot 2) with the losses of cows of Lots 1, 3, 4 and 5 revealed that feeding this supplement resulted in significantly less ($P < 0.01$) weight loss. All other statistical comparisons made of the data from this trial were found to be non-significant. Table IV presents the design of statistical analysis used to analyze the data of this trial. Since the weight loss of the cows fed the 40-percent protein supplement containing approximately 50 percent of the total nitrogen as urea (Lot 5) was greater than when the 20-percent simple protein (Lot 4) or the 40-percent protein supplement (Lot 2) was fed, it appears that little, if any, of the urea was utilized during this trial. Statistical analysis reveals that the weight losses of cows fed supplements which furnished equal protein (Lots 1, 3 and 4) were not significant. The average weight losses for these lots were 324, 273, and 311 lb. per head for Lots 1, 3 and 4, respectively. Although the weight losses

TABLE VII

Weight Gains and Feed Costs of Three-Year-Olds, 1956-57

	Lot 1 40-CSM	Lot 2 40-CSM	Lot 3 20-Comb	Lot 4 20-CSM+Corn	Lot 5 40-Urea
Number of head per lot[1]	14	13	15	10	12
Average weight (lb.)					
Fall 9-26-56	1010	1023	1017	992	1020
Spring 4-26-57	686	768	744	681	699
Winter gain	-324	-255	-273	-311	-321
Weaning 8-5-57	879	951	928	895	978
Gain from spring	193	183	184	214	279
Fall 9-28-57	945	983	985	961	1037
Summer gain	259	215	241	280	338
Yearly gain	-65	-40	-32	-31	17
Cost of protein supplement ($)	10.11	20.22	21.30	20.22	21.25

1. In trial III, there were 16, 15, 15, 11, and 15 cows in Lots 1, 2, 3, 4, and 5, respectively. In Lot 1, 1 cow died and 1 was open. In Lot 2, 1 cow was open and 1 calf died shortly after birth. In Lot 4, 1 calf died during the wintering period. In Lot 5, 3 cows were open.

for Lots 3 and 4 were quite different, the difference was not significant when statistically analyzed. The weight changes of these two lots indicated that the 20-percent combination pellet was of more value for wintering cows than the 20-percent simple protein pellet.

Combined Cow Data for all Trials

A summary of the average production data for the first four years of this study is presented in Table VIII. The summarized data include only the results from those cows originally allotted to this study which have weaned two calves, one in 1956 and one in 1957. The reasons for removal of these cows are summarized in Table IX. Many of these reasons were not related to the experimental conditions imposed upon these cows, but are reasons inherent to any cow herd.

Statistical analysis of the data from the first two years of this study revealed there were no significant differences among treatments (supplements) and between years. Table X presents the design of statistical analysis used to analyze the combined data. During these two years the protein requirement of the cows for maintenance and growth was apparently met equally well by the various supplements. Winter weight losses of all groups increased tremendously the third winter over those of the second winter; however, such losses may be expected since they included both the loss from calving in the late fall and lactation during the winter months.

During these first two feeding seasons the average gains of heifers fed 1.0 lb. and 2.0 lb. of 40-percent protein pelleted cottonseed meal were nearly the same. However, during the winters in which the cows were suckling calves the losses were considerably greater in Lot 1 (1.5 lb. pellets) than in Lot 2 (3.0 lb. pellets). The differences in weight gains in Lots 1 and 2 indicate that the additional nutrients fed to the cattle of Lot 2 were needed and utilized by the animal body. The total gains in the four-year period were 466 and 507 lb. for Lots 1 and 2, respectively.

TABLE VIII

Protein Supplements for Wintering Fall-calving Cows
(four-year average)

	Lot 1 40-CSM	Lot 2 40-CSM	Lot 3 20-Comb	Lot 4 20-CSM + Corn	Lot 5 40-Urea
Number of cows[1]	14	13	15	10	12
Average weight (lb.)					
Initial 11-2-53	479	476	481	495	479
Winter gain 4-12-54	2	6	-2	-9	-13
Fall 10-30-54	680	685	683	684	674
Winter gain 4-19-55	6	-8	-23	-15	2
Fall 10-10-55	977	960	953	956	948
Winter gain 4-24-56	-221	-141	-181	-214	-146
Fall 9-26-56	1010	1023	1018	992	1020
Winter gain 4-26-57	-324	-255	-273	-311	-321
Final 9-28-57	945	983	985	961	1037
Total gain	466	507	504	466	558

1. Twenty heifer calves were originally in each lot, but results are given only for cows which have weaned two calves. Reasons for removal are given in Table IX.

TABLE IX

Reasons for Omitting Cow Data

	Lot 1 40-CSM	Lot 2 40-CSM	Lot 3 20-Comb	Lot 4 20-CSM + Corn	Lot 5 40-Urea
Total heifers at beginning	20	20	20	20	20
Calved spring of 1954	0	0	0	0	0
Died in 1954[1]	0	0	0	1	0
Heifers in 1953-54 trial	20	20	20	17	20
Calved spring of 1955	1	4	1	1	0
Heifers in 1954-55 trial	19	16	19	16	20
Open	3	1	4	3	2
Cows died in 1956[2]	0	0	0	1	0
Calves born dead or died later	0	0	0	1	3
Cows in 1955-56 trial	16	15	15	11	15
Open	1	1	0	0	3
Cows died in 1957	1	0	0	0	0
Calves born dead or died later	0	1	0	1	0
Cows in 1956-57 trial	14	13	15	10	12
Open on 6-21-57	10	5	6	4	6

1. Cause of death unknown.

2. Death was apparently due to accidental causes.

TABLE X

Design of Statistical Analysis for Combined Trials 3 and 4

Source of Variation	d.f.	Mean Square	F
Total	127		
Treatment	4	22,597	7.80
2 vs. 1, 3, 4 and 5	1	18,699	13.83
5 vs. 1, 3 and 4	1	299	
1 vs. 3 and 4	1	5,786	4.30
3 vs. 4	1	680	
Year	1	428,390	151.59
Treatment x Year	4	7,016	2.48
Within	118	2,826	

All groups of cattle lost significantly more ($P < 0.01$) weight during the fourth wintering season than during the third wintering period. Analysis of the combined data for the third and fourth winters revealed a significant ($P < 0.01$) difference in treatments (supplements). The interaction of treatment x year was also found to be significant ($P < 0.05$). A possible explanation of the unusually high weight losses which occurred during the fourth winter is the inability of the cows to adequately replete their body stores due to gestation and the shortage of forage in the native grass pastures during the unusually dry summer of 1956.

Considerable variation existed among the various supplements in their ability to reduce weight losses during the third and fourth winters when lactation became an additional factor in the protein requirement. Analysis of the combined data for these two years showed

that the winter weight losses of the cattle (Lot 2) fed 3.0 lb. of the 40-percent protein pellet were significantly less ($P < 0.01$) than the weight losses of the other groups. The design of analysis of the combined data from trials 3 and 4 is presented in Table X. This indicates that the greatest need for supplemental feed was for protein and not energy or some of the other nutrients which may have been furnished. The cows in Lot 2 were the only cattle in the experiment that appeared to be in a relatively satisfactory condition as judged by their general appearance during the winter.

When urea was added to a supplement containing 20 percent protein (Lot 4) in such amounts that the protein content (N x 6.25) of the pellet was increased to 40-percent (Lot 5), the average winter losses for the first two years were nearly the same for both groups of cattle. While suckling their first calves (trial 3), the cows fed the urea-containing pellet lost considerably less weight than those in Lot 4. However, during trial 4, differences in weight gains were slightly in favor of Lot 4. In the statistical analysis of combined trials 3 and 4, the losses of the cows in Lot 5 were compared to the losses occurring in Lots 1, 3 and 4. These weight loss differences were not significant, indicating that the urea-containing pellet was not superior to its negative controls, which were the supplements fed in Lots 1, 3 and 4.

The winter losses as calves and yearlings were practically the same in both groups fed the 20-percent protein pellets (Lots 3 and 4). However, while suckling calves (winters 3 and 4) the cows fed the combination pellet (Lot 3) lost significantly less ($P < 0.05$) weight than those fed the corn and cottonseed meal pellet (Lot 4). Statistical

comparison of these two supplements in individual years (years 3 and 4) showed no significant differences, but when combined, they are significantly different. These weight changes suggest that the ingredients furnished in the combination pellet apparently provide increased quantities of certain nutrients needed by range cattle for increased utilization of the forage.

Gains during the first two years were slightly in favor of 1 lb. of 40-percent protein pellet when a comparison of the three pellets furnishing equal protein but a considerable difference in amounts of other nutrients is made. The cattle in Lots 3 and 4 were fed twice as many pounds of their respective 20-percent protein pellet as the cattle in Lot 1. During the next two years the added nutrients fed Lots 3 and 4 resulted in significantly less ($P < 0.05$) winter weight loss. One of the main additions to the 20-percent protein pellets was energy supplied by grain. The results indicate that this added energy (and other nutrients) was needed and utilized by the animal body. However, the provision for adequate protein seems to be more valuable than added energy.

Growth of the cows in this study was measured each year by taking a photograph of each animal while standing behind a grid. Table XI presents the average growth data only for those cows which have weaned two calves, one in 1956 and one in 1957. All groups of cattle followed a general growth pattern indicating that the nutritional regime upon the cattle had little effect upon their growth. The most rapid growth occurred when all cows were calves and yearlings, with only a small amount of growth being evident after the first calf.

The cost of supplemental feed during the winter may very often be

TABLE XI

Average Growth Rate of Cows[1]

Measurements	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Height at withers (inches)					
Calves	39	39	39	39	39
Yearlings	44	45	44	42	43
Two-year-olds	45	45	46	44	45
Three-year-olds	49	49	46	46	46
Chest floor to ground (inches)					
Calves	19	19	19	19	19
Yearlings	21	21	21	21	21
Two-year-olds	21	22	21	21	21
Three-year-olds	23	22	23	22	23
Horizontal Length Point of shoulder to pinbone (inches)					
Calves	41	40	40	41	41
Yearlings	46	47	48	46	46
Two-year-olds	51	50	51	49	52
Three-year-olds	51	51	52	50	52

1. Data presented in this table includes only those measurements from cows which have weaned two calves.

the determining factor as to whether or not a cow-and-calf production system is financially profitable. Table II presents the cost of the various pellets for each year. On the basis of a four-year average, the cows (Lot 1) fed the lower level (1.5 lb. pellet) of the 40-percent protein pellet were the most economical to winter, but were in the poorest condition the following spring after suckling a calf. The cows (Lot 2) fed the higher level (3.0 lb. pellet) of the same supplement were the most economical of any of the four groups, which were fed 3.0 lb. of their respective supplement. The 20-percent combination pellet (Lot 3) was the most expensive pellet fed during the four years of this study. The cost of the 20-percent simple pellet (Lot 4) was approximately twice that of the lower level (1.5 lb.) of the 40-percent protein pellet; however, the total gain made by the cows in Lot 4 was no better than that made by the cows in Lot 1, thus, the added cost was not reflected in added gains. The urea-containing pellet was intermediate in both cost and production ability.

Combined Calf Data for Trials 3 and 4

The combined calf data reported in Table XII includes only those calves from cows which weaned a calf in 1956 and 1957. The data summarized in this manner presents a more precise evaluation of the various protein supplements fed in this study.

The average birth weights of the calves in the 1955-56 study were practically the same. In the 1956-57 test the average birth weights were more variable being 76, 75, 77, 74, and 73 lb. for Lots 1, 2, 3, 4 and 5, respectively. The cows calved in late fall and early winter after the feeding period had started. Thus, an additional protein

TABLE XII

Calf Data, 1955-56 and 1956-57

	Lot 1 40-CSM	Lot 2 40-CSM	Lot 3 20-Comb	Lot 4 20-CSM + Corn	Lot 5 40-Urea
			1955-56		
Number of steers	6	4	6	6	5
Number of heifers	8	9	9	4	7
Average birth date, 1955	10/30	11/23	11/4	11/12	11/14
Average birth weight[1]	74	73	74	74	75
Average weight 4-24-56[2]	194	239	219	205	212
Average daily gain to 4-24-56	.73	1.00	.88	.79	.83
Average final weight 8-4-56[3]	389	436	413	415	426
			1956-57		
Number of steers	8	9	7	2	6
Number of heifers	6	4	8	8	6
Average birth date, 1956	10/21	10/13	10/14	10/11	10/16
Average birth weight[1]	76	75	77	74	73
Average weight 4-26-57[4]	180	220	197	197	192
Average daily gain to 4-26-57	.55	.76	.63	.65	.63
Average final weight 8-4-57[5]	333	405	394	437	381

1. Corrected for sex by adding 3 lb. to the actual birth weight of each heifer.
2. Corrected for age by adjusting all calves to a standard age of 165 days, and for sex by adding 16 lb. to the age-corrected weight of each heifer.
3. Corrected for age by adjusting all calves to a standard age of 270 days, and for sex by adding 20 lb. to the age-corrected weight of each heifer.
4. Corrected for age by adjusting all calves to a standard age of 190 days, and for sex by adding 16 lb. to the age-corrected weight of each heifer.
5. Corrected for age by adjusting all calves to a standard age of 290 days, and for sex by adding 20 lb. to the age-corrected weight of each heifer.

requirement for final development of the fetus was encountered. It appears that the kinds and amounts of protein supplement fed in these trials had little effect on the average birth weight or the average birth date of the calves. However, the supplements were fed for such a short time of this later part of the gestation period that they had very little time to exert an influence on birth weights of the calves.

There was a significant difference ($P < 0.01$) in the calf weights among the treatments of their dams at the end of the winter feeding period. The design of statistical analysis used in the analysis of the calf data is reported in Table X. The calves from cows of Lot 2 were significantly heavier ($P < 0.01$) than the calves from any of the other lots. In April of 1956, the Lot 2 calves weighed 239 lb., which was 31 lb. greater than the average weight of the other four lots. In April of 1957, this difference was 29 lb. Lot 1 calves were significantly lighter ($P < 0.05$) than the calves from Lots 3 and 4. The average weights of the calves from Lots 1, 3 and 4 were 187, 208 and 201, respectively, at the end of the winter feeding period. A non-significant difference resulted from comparing the calf weights of Lot 5 with those of Lots 1, 3 and 4. There was a significant ($P < 0.01$) year difference of the calf weights at the end of the winter feeding period in favor of the 1955-56 calves.

Weaning weights were significantly different ($P < 0.01$) among the treatments of their dams. The weaning weight of the calves from the cows of Lot 2 was significantly heavier ($P < 0.01$) than the weaning weight of the calves from the other lots. The weaning weights in Lot 2 were 436 and 405 lb. in trials 3 and 4, respectively. Calves from the Lot 1 cows weighed significantly less ($P < 0.01$) than the calves from Lots 3

and 4. The average difference was 25 lb. in trial 3 and 82 lb. in trial 4. The weights in Lots 3 and 4 were practically the same in trial 3. In trial 4, there was a considerable difference. Statistical analysis of the combined data indicated that these differences were not significant. The 1956-57 weaning weight of the Lot 5 calves was 426 lb. which was 20 lb. greater than the average weaning weight of the calves from Lots 1, 3 and 4. In 1956-57, this difference was only 7 lb. These differences were found to be non-significant when statistically compared. The weaning weights of the calves in the 1956-57 trial were significantly lighter ($P < 0.01$) than the weaning weights of the calves in the 1955-56 trial.

The growth rate data of the calves obtained at the end of the feeding period presents a more valid estimate of the value of the supplements fed to the calves' dams than does the weaning weight, since this measurement is taken before the spring grass has a chance to mask the effects of supplemental feeding.

Feeding 3.0 lb. of the 40-percent protein pellet to the cows of Lot 2 resulted in their being heavier at the end of the feeding period as well as at weaning.

SUMMARY

Four trials were conducted with one hundred Hereford heifer calves to study the value of different protein supplements fed during four consecutive winters to cattle grazing native grass pasture yearlong. The protein supplements and the amount of each fed during the first two winters were as follows: Lot 1, 1.0 lb. of 40-percent protein pelleted cottonseed meal; Lot 2, 2.0 lb. of the same supplement as fed in Lot 1; Lot 3, 2.0 lb. of 20-percent protein combination pellet; Lot 4, 2.0 lb. of 20-percent protein pellet (CSM and corn); and Lot 5, 2.0 lb. of 40-percent protein pellet containing urea. At the beginning of the winter feeding period for 1955-56, the allowance of supplemental feed was increased to 1.5 lb. per head daily in Lot 1 and 3.0 lb. per head daily in the other lots. Winter gains of cows, winter gains of calves, and weaning weights of calves were used as measurements to determine the relative value of the supplements. The results indicated that feeding the higher level of the 40-percent protein pellet to commercial beef cattle grazing dried native grass was the most desirable practice ($P < 0.01$). Feeding the lower level of pelleted cottonseed meal was the least desirable practice. Only minor differences resulted in production due to feeding the two 20-percent protein pellets or the urea-containing pellet. Based on combined trials 3 and 4 results, the 20-percent protein combination pellet was apparently no more desirable than a 20-percent simple protein pellet when measured by weaning weights of calves, but was slightly superior for preventing winter weight losses of cows.

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