A STUDY OF VARIOUS SUBSTITUTES FOR CORN AND COTTONSEED MEAL FOR FATTENING STEER CALVES

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By

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INTRODUCTION

The South, and particularly the Southwest, has need for additional concentrate feed to use in finishing cattle. The demand for protein supplements and carbonaceous feeds in recent years has encouraged the feeding of substitutes for such standard feeds as corn and cottonseed cake.

It is highly important in fattening calves to know definitely how much protein supplement should be added to the ration. Protein feeds are important, but a costly part of the ration, as a rule, if fed in excessive amounts. There is a need for investigation of the proper protein levels to feed in certain calf fattening rations.

Approximately 55,000 acres of mungbeans were grown in Oklahoma during 1949. Although mungbeans are commonly planted for forage and soil building, the green variety is a prolific seed producer and was grown extensively during the recent war years for sprouting purposes. A considerable amount of cracked and cull beans became available for livestock feeding. Satisfactory results have been obtained at the Oklahoma station in testing the green mungbean seed as a source of protein for poultry, swine, lambs and dairy cattle.

The shortage of protein supplements has created a need for finding means of extending the protein supply. It has been shown that urea nitrogen can be utilized by rumen micro-organisms. The micro-organisms convert the urea nitrogen into bacterial protein which upon the death of the bacteria is digested and utilized by the ruminant in the same manner as other proteins are digested and utilized. The use of urea as a substitute for part of the true protein in fattening rations of cattle has been demonstrated, but additional studies appear to be needed to determine the practical value of such a nitrogen compound when added to fattening rations.

Carotene or vitamin A deficiencies of steers that are fattened in the

dry lot are not uncommon. Vitamin A is the vitamin most likely to be lacking in beef cattle fattening rations. It would appear desirable to determine the advisability of adding additional carotene to practical fattening rations.

GENERAL EXPERIMENTAL METHODS

Choice Hereford weanling calves were purchased each year from the Mullendore Trust Company ranches for the feeding trials reported in this paper. The calves were allotted uniformly according to standard experimental procedure with 10 head to each lot. The feeding trials were begun each year about the fifteenth of October and terminated about the fifteenth of April.

The steers of each lot were confined to concrete paved pens approximately 50 x 30 feet in size and had access to an open shed shelter. The feedbunks in each lot were placed under the open shed. The feed for each lot was weighed at each feeding, and all lots of steers were hand fed. The alfalfa hay was fed separately each morning, but all the other feed ingredients were fed twice daily. The grain and protein supplements for each lot were mixed with the silage. Any refused feed was weighed back. All lots were allowed free access to salt and a mineral mixture consisting of equal parts salt, bone meal and ground limestone.

The steers were weighed each 28 days. The initial and final weights were determined by averaging the weights from three consecutive days of weighing.

The initial cost price in each instance was the actual cost price of the steers. The value per cwt. at the conclusion of each trial was determined by a committee from the Oklahoma City livestock market composed of packer and commission company representatives. This value is referred to as the appraised value throughout the paper.

PART I MUNGBEANS

REVIEW OF LITERATURE

Mungbeans can be successfully grown in Oklahoma. The green variety is a prolific seed producer and is commonly planted for feed and soil building, according to Ligon (1945). Although mungbeans have been grown in Oklahoma for about twenty years (Kuhlman, 1946), it was only during World War II that Oklahoma farmers became interested in growing green mungbeans on an extensive scale. While most of the yearly production is sold for sprouting, a considerable amount of cracked and cull beans are available for livestock feeding.

Heller (1927) reported that green mungbeans contained 23.31 percent crude protein and 59.85 percent nitrogen-free-extract. The Oklahoma Station chemist also reported that carotene was present in amounts greater than in many feeds.

Thompson and Hillier (1942) conducted a feeding trial, testing ground green mungbeans with four breeds of swine. They obtained data indicating that mungbeans were a satisfactory substitute for 43 percent cottonseed meal in the standard mixture of two parts meat scraps, one part cottonseed meal and one part dehydrated alfalfa leaf meal. The beans were not a satisfactory substitute for the protein of meat scraps and cottonseed meal when the mungbeans and dehydrated alfalfa were fed as the sole supplements to corn.

Ligon (1945) briefly summarized the testing of green mungbean seed at the Oklahoma Station as a source of protein in rations of poultry, swine, lambs and dairy cattle. He reported that ground green mungbeans satisfactorily replaced soybean or cottonseed meal in both laying and growing mashes.

When the beans were supplemented with some animal protein and 2 percent bone meal, satisfactory results were obtained when they made up 40 percent of the mash.

Oklahoma workers reported in Science Serving Agriculture (1942-44) that mungbeans satisfactorily replaced two-thirds of the cottonseed and soybean meal commonly used in starter rations for turkeys. The beans were found to contain protein of higher quality for turkey poults than for chickens.

Briggs (1943) fed cracked mungbeans as a protein supplement in two fattening trials with feeder lambs. The beans were fed at a level to supply from one-half to two-thirds of the protein required to balance a ration of corn and prairie hay. The beans were not palatable beyond 0.35 pound per head daily, so some additional cottonseed meal was fed to meet the protein requirement. Digestibility of the protein in the mungbeans was equal to that of cottonseed meal. Briggs (1945) investigated the digestibility of green mungbean seed by wether lambs when fed with a desirable grade of prairie hay. The apparent average digestion coefficient of the protein in the beans was 84.0 percent; the nitrogen-free-extract had an apparent digestion coefficient of 90.0 percent. These studies showed the biological value of the protein in this type of ration to be similar to that found in rations supplemented with more commonly fed vegetable proteins.

Kuhlman, et al. (1946) reported two 90-day dairy cow feeding trials, each consisting of three 30-day periods conducted on the double reversal plan and including a total of 25 cows. Prairie hay of good quality was fed as the sole roughage. When mungbeans were added to a concentrate mixture at the expense of 60 percent of the cottonseed meal and approximately 43 percent of the corn of a good dairy ration, they found that 300 pounds of

ground mungbeans satisfactorily replaced 150 pounds of corn and 150 pounds of cottonseed meal. Two additional unpublished feeding trials were conducted by Oklahoma workers (1949), in which mungbeans satisfactorily replaced all of the cottonseed meal in the dairy ration. The mungbeans constituted almost 50 percent of the concentrate mixture.

The research reported at the Oklahoma Station involving studies with livestock and poultry indicate that mungbeans can satisfactorily replace part of the corn and all of the cottonseed meal in dairy rations, and can replace all the soybean or cottonseed protein in poultry and swine rations. The mungbeans were not a satisfactory substitute for animal protein such as meat and bone scraps or tankage. If the relative price of mungbeans is approximately comparable to that of other vegetable proteins, such a feed appears to have considerable value as a substitute for cottonseed or soybean meal and a partial replacement for corn in livestock feeding.

EXPERIMENTAL

During a three year period, 1946 to 1949, the value of green mungbeans as a beef cattle feed was investigated. Two uniform lots of choice Hereford calves were placed on experiment each of the three years. The following daily rations were fed:

	Lot 1	Lot 2
Ground yellow corn	Full fed	Full fed
Cottonseed meal or cake	1.5 pound	none
Ground green mungbeans	none	About 2.5 pounds
Atlas sorgo silage	Limited	Limited
Alfalfa hay	1.0 pound	1.0 pound
Salt	Ad lib	Ad lib
Mineral mixture	Ad lib	Ad lib

The gound green mungbeans were fed at a level to provide the same crude protein intake daily as that provided by 1.5 pounds of cottonseed meal or cake. Cottonseed meal was fed during the first two years, and cottonseed cake was fed the third year.

The average data for the three trials are presented in Table 1. The average chemical analysis of the feeds fed are presented in Table 2.

RESULTS AND DISCUSSION

When ground green mungbeans replaced all of the cottonseed meal or cake in the fattening steer calf ration, the average daily gains were the same for each of the lots in the first two trials. The average daily gain of each lot in the first trial was 2.13 pounds, and in the second trial the

Table 1. Comparison of Mungbeans and Cottonseed Meal
Average of Three Years, 1946-1947, 1947-1948, 1948-1949.

(Average Number of Days Fed, 171)

Lots	I	II
Ration	Gr. corn C. S. M. Silage Alfalfa	Gr. corn Gr. Mungbeans Silage Alfalfa
No. steers per lot	30	30
Average wt. per steer (lbs.)		
Initial	512	511
Final	873	876
Gain	361	365
Average daily gain	2.11	2.13
Average daily ration (lbs.)		
Ground corn	11.43	9.90
Cottonseed meal or cake	1.50	----
Ground Mungbeans	----	2.54
Alfalfa hay	1.00	1.00
Silage	8.53	8.27
Salt	.02	.02
1-1-1 mineral mixture	.02	.02
Feed per cwt. gain (lbs.)		
Ground corn	541	465
Cottonseed meal	71	---
Ground Mungbeans	---	119
Alfalfa hay	47	47
Silage	403	388
Salt	1.0	0.9
1-1-1 mineral mixture	1.0	0.8
Feed cost per cwt. gain (dollars)	22.19	21.26
Financial results (dollars)		
Appraised value per cwt.	26.25	26.42
Total value per steer (3% shrink)	222.34	224.57
Initial cost @ $23.17 per cwt.	118.63	118.39
Feed cost [1]	80.10	77.60
Total steer and feed cost	198.73	195.99
Profit per steer	23.61	28.58

[1]The prices of feed were: Ground corn $3.41 per cwt., cottonseed meal $90.50 per ton, ground green mungbeans $81.67 per ton, alfalfa hay $22.00 per ton, silage $5.67 per ton, salt $0.83 per cwt., and mineral mixture $2.13 per cwt.

TABLE II

Chemical Composition of Feeds Used in Table I

		Percent Composition of Dry Matter						
	% D. M.	Ash	Protein	Fat	Fiber	N.F.E.	Ca	P
Green mungbeans	89.81	3.98	25.33	1.57	3.99	65.13	.14	.38
Yellow corn	87.38	1.49	9.55	4.97	2.25	81.74	.05	.30
Cottonseed meal	92.36	6.32	42.58	6.08	11.98	33.04	.22	1.12
Atlas sorgo silage	49.70	7.70	4.48	2.09	23.74	61.99	.28	.32
Alfalfa hay	92.45	8.74	15.91	2.79	34.34	38.22	1.55	.25

average daily gain of each lot was 2.14 pounds. During the third trial the mungbean fed steers gained 0.05 pound more daily than those fed cottonseed cake. The average daily gain for the three trials was 2.11 and 2.13 pounds for the cottonseed meal and the mungbean fed steers, respectively. The differences in gains were not statistically significant.

The steers of Lot 2 were fed 2.54 pounds of mungbeans. Although the corn was full fed to the steers of both lots, the mungbean steers ate 1.53 pounds less corn daily than the steers of Lot 1. Less feed was required per cwt. gain for the steers of Lot 2, and they were slightly fatter as indicated by the higher appraised value per cwt. than those of Lot 1.

In these trials 100 pounds of ground mungbeans replaced 59.7 pounds of cottonseed meal or cake, 64 pounds of corn and 13 pounds of silage. On the basis of the average prices of feed fed in these trials, 100 pounds of mungbeans fed as a protein supplement was equal in value to 109 pounds of cottonseed meal or cake. As partial replacement for corn in the ration 100 pounds of mungbeans was equal in value to 144 pounds of corn.

SUMMARY

Green mungbean seed when fed as a part of a fattening steer calf ration satisfactorily replaced all of the cottonseed meal or cake and part of the corn in the ration. The mungbeans were quite palatable, and no trouble was encountered in keeping the steers on full feed. When the price of green mungbean seed is equal to that of cottonseed cake or meal, mungbeans can be an economical protein supplement for fattening beef calves. The practice of producing a home grown protein supplement offers considerable promise in Oklahoma.

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PART II UREA

REVIEW OF LITERATURE

The shortage of protein supplements in recent years has created a need for finding means of extending the protein supply. Urea, as a partial replacement for the protein of ruminants, has proven satisfactory in many investigations. Use of urea in practical fattening rations has not been tested extensively.

The mechanism of urea utilization was first clearly demonstrated by Voltz (1920) in metabolism experiments with sheep. He explained urea utilization by stating that amino acids and proteins were synthesized from urea by micro-organisms in the rumen with the urea being incorporated into bacterial protein. His metabolism experiments indicated that approximately 80 to 90 percent of the protein of the dead bacteria was absorbed from the intestine. Honcamp (1924) further clarified this process in urea feeding experiments with milk cows. He found that urea, in a diet containing a normal amount of protein and suitable carbohydrate, was able to replace 30 to 40 percent of the protein without impairing milk production. An extensive review of the German research has been compiled by Krebs (1937).

The first intensive research in the United States concerning the nutritional value of urea was conducted by Hart and co-workers at the Wisconsin Station beginning in 1936. Their initial experiments with two lots of growing calves fed both urea and ammonium carbonate for periods up to 40 weeks were reported in 1939. The growth rate for a 16-weeks period was 1.5 pounds and 1.3 pounds daily on casein and urea rations, respectively. Approximately 43 percent of the total nitrogen in the ration of those fed urea consisted of urea nitrogen.

Wegner extended this work to include rumen fistula studies (1940,1941). Examination of rumen ingesta removed from the fistulated cow demonstrated that urea or ammonium nitrogen disappeared within 4 to 6 hours after feeding with a corresponding increase in total protein nitrogen. Wegner also found that the rate of conversion of urea to protein nitrogen in the rumen decreased as the total protein level of the rumen ingesta became greater than 12 percent. Rumen fistula studies were continued by Mills and coworkers (1942-1944) who found the utilization of urea was markedly improved when readily available carbohydrate was added to a basal ration composed largely of timothy hay. Pearson and Smith (1943, 1944) carried out extensive "in vivo" experiments and reported that the initial conversion of urea into ammonia and carbon dioxide occurred largely within one hour. The ammonia was readily utilized by the bacteria and other microflora in the rumen.

Work, et al. (1943) reported that urea when fed for long periods of time to steers in a dry lot at the rate of 0.88 percent and 2.29 percent of the dry matter of the ration did not cause kidney or liver damage. Steers fed 2.29 percent of the dry matter of the ration as urea did not make as good gains as the steers fed urea at the rate of 0.88 percent of the dry matter in the ration. Steers on pasture fed 0.18 and 0.35 pound of urea per day as the complete replacement of cottonseed meal did not show any kidney or liver damage.

Loosli and McCay (1943) found that calves two months of age were unable to grow on a ration containing only 4.4 percent protein. However, when urea was added to the ration to give a calculated protein content of 16.2 percent, the calves increased in body weight and height at a fairly satisfactory rate.

Swift, et al. (1947) studied the effect of urea supplementation on digestibility and concluded that urea feeding resulted in an increase in the digestibility of protein by lambs. Briggs (1948), in metabolism work with lambs, found that adding urea to a basal ration of low protein prairie hay increased the apparent digestibility of the hay nutrients.

McNaught and Smith (1947) reviewed many experiments that have been conducted during the last few years in different countries on the value of dietary nonprotein-nitrogen for milk production of ruminants. They summarized the findings of other investigators who studied and reviewed the urea nitrogen metabolism in the rumen.

The most conclusive evidence supporting the theory of bacterial protein synthesis has been published recently by Loosli, et al. (1949). They fed a purified diet to sheep and goats. When the ruminants were fed a ration containing no supplementary nitrogen other than urea, they gained in live weight and maintained a positive nitrogen balance. Analysis of rumen contents and excreta showed definitely that the micro-organisms of the paunch were able to synthesize all ten of the essential amino acids in large amounts.

The possibilities of supplementing the rations of range cattle and fattening cattle in the feed lots with urea and fortified urea pellets has only recently been explored. Oklahoma workers reported preliminary urea tests with fattening steers in the Biennial Report of Science Serving Agriculture (1942-1944). When urea was used to supply practically all of the nitrogen in the ration, full fed steers found it much less palatable than 43 percent cottonseed meal. They gained only 1.62 pounds as compared to 2.03 pounds for steers fed cottonseed meal. Weber (1944) reported the results of two steer fattening trials in which urea was compared to cottonseed

meal as the sole source of supplemental nitrogen. In the first trial steer calves were individually fed a fattening ration for 168 days. The ration in which urea provided the supplemental nitrogen was equally as palatable and produced as large gains as the ration in which cottonseed meal was the source of additional nitrogen. In the second trial steers were group fed the same rations as those that had been individually fed. In this trial the steers that were fed the cottonseed meal made greater gains and required less feed per 100 pounds of gain than those fed urea. In a 120-day feeding trial in 1944 the value of urea was studied at the Kansas Station in a wintering ration for 365 pound calves. With silage fed as the roughage, the steers fed cottonseed meal had slightly better appetites, and the gains were slightly greater than the gains of the steers fed urea and urea plus ground corn, respectively. In a further wintering trial with yearling steers, Weber (1945) compared cottonseed meal and a mixture of urea, ground corn and bone meal as supplements to silage and prairie hay ration. He concluded from these tests that urea should not be depended upon to supply the greater part of the nitrogen in a supplementary mixture used to replace cottonseed meal in a beef cattle wintering ration.

Hart (1946), reported that a solution of urea in blackstrap molasses, offers an ideal supplement for use with dried forage crops, beet pulp and range pastures. Kinney (1946) reviewed two additional trials on the utilization of urea in the fattening steer ration at the Oklahoma Station. Three lots of ten head each were fed corn and prairie hay plus supplements of urea Formula 1, urea Formula 2, or cottonseed meal for a period of 153 days. Twenty-five percent of the total nitrogen of Formula 1 was in the form of urea, and 50 percent of the total nitrogen of Formula 2 was urea nitrogen. The calves receiving 25 percent of their supplemental protein

nitrogen in the form of urea gained 1.96 pounds daily as compared with 1.98 pounds daily for those receiving 50 percent of their supplemental nitrogen in the form of urea and 1.81 pounds daily for those supplemented with cottonseed meal. There was very little difference in the amount of feed required per 100 pounds of gain, but calves fed the ration supplemented with Formula 2 had the lowest feed requirements, and those fed cottonseed meal had the highest feed requirement. In a similar fattening experiment conducted in 1945-1946, covering a period of 167 days, it was found that younger calves supplemented with cottonseed meal gained faster and required slightly less feed per 100 pounds gain than calves supplemented with either 25 or 50 percent urea containing pellets. The average daily gains secured were 1.86 pounds for those supplemented with cottonseed meal, 1.77 pounds for the calves getting 25 percent of their supplemental nitrogen from urea and 1.61 pounds for those receiving 50 percent of their supplemental nitrogen in the form of urea.

Formulas used in fattening, digestion and metabolism trials reported by Kinney (1946) were:

Formula I	Formula II
10% Blackstrap molasses	10% Blackstrap molasses
4% Du Pont's "262" [1]	8% Du Pont's "262"
11% Hominy feed	32% Hominy feed
75% Cottonseed meal	50% Cottonseed meal

[1] "Two-Sixty-Two" feed compound is produced by the Du Pont and Company. It contains 42 percent nitrogen in the form of urea which when multiplied by 6.25 gives an equivalent protein value of 262 per cent. Stated simply, 1 pound of "262" is equivalent to 2.62 pounds of protein.

Briggs, et al. (1946) reported that steers in metabolism stalls made satisfactory use of the nitrogen of urea in a corn and prairie hay ration when it replaced 25 to 50 percent of the cottonseed meal nitrogen. Satisfactory results were also obtained when urea replaced 25 to 50 percent of the cottonseed meal nitrogen in the protein supplement fed to fattening calves in the dry lot. In summarizing the results of these trials, Briggs, et al. (1947) reported that the protein pellets containing 50 percent urea nitrogen and 50 percent cottonseed meal nitrogen were a satisfactory supplement in the early phases of the fattening period, but were not palatable in later phases. The various supplements were fed with corn and prairie hay.

Briggs, et al. (1947) reported that yearling heifers fed a pellet containing 25 percent urea nitrogen and 75 percent cottonseed meal nitrogen made slightly more rapid gains than those fed cottonseed meal. Pregnant cows wintered satisfactorily when fed such a urea-cottonseed meal pellet. Urea at the levels fed did not produce toxic symptoms when full fed to growing calves.

Stephens, et al. (1948) reported the results of three trials comparing cottonseed cake, soybean cake and urea-cottonseed meal pellet as protein supplements for wintering two-year-old steers grazing dry native grass. On the basis of winter gain the soybean cake was superior to either cottonseed cake or urea pellets, when fed at the rate of 3 pounds per head daily.

Marion, et al. (1948) found urea to be an excellent protein supplement in the fattening ration of yearling steers. In this study, a 43 percent protein supplement containing urea was compared with 43 percent protein cottonseed meal. The urea-cottonseed meal supplement was prepared from 36 percent protein cottonseed meal by the addition of 2.3 percent of "Two-Sixty-Two" urea feed compound. Practically no difference in gain was observed

between the steers of the two lots fed these rations. Schrum and Riggs (1948) obtained data in two feeding trials with steer calves and yearling steers that indicated protein supplements containing urea are almost equal in feeding value to protein supplements from natural sources. The following protein supplements were compared in the 1947 fattening trial:

(1) Forty-three percent crude protein cottonseed meal.

(2) A mixture of cottonseed flour, peanut meal and soybean meal containing 54 percent crude protein. Urea was added at such a level to increase the crude protein equivalent of the mixture to 70 percent.

In the 1948 feeding trial Schrum and Riggs made the following comparison of protein supplements:

(1) Forty-three percent crude protein cottonseed meal was compared with 36 percent crude protein cottonseed meal made up to 43 percent crude protein equivalent with urea.

(2) Fifty-four percent crude protein cottonseed meal was compared with 54 percent crude protein cottonseed meal made up to 70 percent crude protein equivalent with urea.

Fewer pounds of the higher crude protein feeds containing urea were needed to supply the same amount of protein. The energy value of the rations was balanced by feeding slightly more grain to the steers fed the supplements containing urea.

Watson, et al. (1949) conducted feeding and slaughter trials with beef calves. They fed a protein poor basal ration and added urea or casein as the sole source of added protein. The basal ration contained 17.5 percent molasses. The beef calves fed the casein rations made appreciably greater live weight gains, and the body protein and ash was greater than

that of steers fed urea. In further studies of the nutritive value of nitrogen compounds, Watson, and others (1949) stated "urea containing approximately 30 atom percent N^{15} was fed to sheep for four days. The proteins separated from the liver, blood and kidneys contained N^{15} in excess of normal abundance." It was concluded that some nitrogen from urea was utilized by ruminants for the formation of body proteins.

Baker, et al. (1949) compared urea with soybean meal in a feeding trial with four lots of steer calves and reported that there was very little difference in the finish and appearance of the steers. The average initial weight of the calves was 490 pounds, and they were full fed corn silage and ground corn for 154 days. There was no apparent difference among the lots fed either 0.173 pound urea plus 0.04 pound steamed bone meal, or 0.087 pound urea plus 0.02 pound of steamed bone meal, in addition to 0.63 pound soybean oil meal, or those fed 1.46 pounds soybean oil meal as supplements daily. Baker, et al. (1949) reported that feeding of 1.5 pounds of a mixture in which 9.8 percent of "Two-Sixty-Two" feed compound replaced an equal amount of dehydrated alfalfa meal resulted in larger gain and lower feed requirements per unit of gain than the feeding of 1.5 pounds of dehydrated alfalfa meal to fattening steers.

EXPERIMENTAL

In the fall of 1946 studies were initiated to determine the value of urea when added to a practical steer fattening ration. During the first two years three lots of choice weanling Hereford Steer calves were fed the following rations:

	Lot 1	Lot 2	Lot 3
Ground yellow corn	Full fed	Full fed	Full fed
Atlas sorgo silage	Restricted Amount	Restricted Amount	Restricted Amount
Alfalfa hay	1.0 pound	1.0 pound	1.0 pound
Cottonseed meal	1.5 pounds	None	None
Urea pellets #1	None	1.5 pounds	None
Urea pellets #2	None	None	1.5 pounds
Salt	Free choice	Free choice	Free choice
1-1-1 Mineral Mixture	Free choice	Free choice	Free choice

The ground corn was full fed in accordance to appetite. The silage was hand fed and restricted in amount to provide maximum consumption of corn. The urea pellets #1 were made of cottonseed meal, urea (Du Pont's "Two-Sixty-Two" urea feed compound), molasses and hominy feed. The urea was added at a level to provide 25% of the total nitrogen of the pellets, and the cottonseed meal provided 75% of the total nitrogen. The urea pellets #2 were made of the same feed ingredients, but the proportion of each adjusted so that 50% of the total nitrogen of the pellets was provided by urea and 50% provided by the cottonseed meal.

The performance of the steers fed the urea pellets was quite satisfactory and approximately equal to that of steers fed cottonseed meal. It was considered possible that in each trial urea pellets #1 or #2 may have supplied sufficient cottonseed meal nitrogen to meet nitrogen requirements of the steers. Although it was assumed that a considerable quantity of the urea nitrogen was utilized by the steers, the data were not conclusive.

To determine further the value of urea in a steer fattening ration an experiment was started in the fall of 1948 in which 1.0 pound of urea pellets #2 were fed daily as the protein supplement with essentially the same ration fed in trials one and two and compared to 1.0 pound of cottonseed cake. Such an experiment provided a more rigorous test of the value of urea than the first two trials. The following rations were fed:

	Lot 1	Lot 2
Ground yellow corn	Full fed	Full fed
Silage	Restricted Amount	Restricted Amount
Alfalfa hay	1.0 pound	1.0 pound
Cottonseed cake	1.0 pound	None
Urea pellets #2	None	1.0 pound
Salt	Free choice	Free choice
1-1-1 Mineral mixture	Free choice	Free choice

During the year 1949-50 the design was changed slightly. Urea pellets #2 were apparently utilized equally as well as cottonseed meal in the first two trials. In the third trial when fed at the level of 1.0 pound per steer per day the performance of the steers was not as satisfactory as that of steers fed 1.0 pound of cottonseed cake. For the fourth trial (1949-50) urea pellets #2 were fed at the 1.5 pound level for approximately the first 60 percent of the feeding period and at the 0.5 pound level for the remainder of the trial. Honey Drip sorghum silage was fed during the fourth trial in place of the Atlas Sorgo silage.

Formulas Used in Urea Pellets

Urea Pellet #1	Urea Pellet #2
10% Blackstrap Molasses	10% Blackstrap Molasses
4% Du Pont's 262	38% Du Pont's 262
11% Hominy Feed	32% Hominy Feed
75% Cottonseed Meal	50% Cottonseed Meal

RESULTS AND DISCUSSION

The data for the first two trials are presented in Table III and the data for trials three and four are presented in Tables V and VII, respectively. The average daily gains for the first two trials were 2.14, 2.11, and 2.17 pounds for the steers fed 1.5 pounds of cottonseed meal (Lot 1), urea pellets #1 (Lot 2) and urea pellets #2 (Lot 3), respectively. There was no statistically significant difference in average daily gain among the three lots. The steers fed urea pellets #2 returned $1.04 more profit per steer than the steers fed cottonseed meal. The average appraisal price of both lots of steers was $26.75 per cwt. at the conclusion of the trials. On the basis of feed required per cwt. gain, 100 pounds of urea pellets #2 replaced 103 pounds of cottonseed meal, 13 pounds of corn and 14 pounds of silage. In these two trials, 100 pounds of urea pellets #2 was equal in value to 114.4 pounds of cottonseed meal.

One steer of Lot 2 was a chronic "bloater" and was removed. The data of Lot 2 are calculated on the basis of 19 steers. The steer removed had made average gains until the condition developed. The steers of Lot 2 fed urea pellets #1 gained slightly less and were appraised at $0.63 less per cwt. than those of Lot 1 fed cottonseed meal. The urea pellet #1 fed steers required less feed per cwt. of gain, but the difference in appraised price and less total gain resulted in less return per steer than the return of those fed cottonseed meal. On the basis of feed required per cwt. gain, 100 pounds of urea pellets #1 replaced 100 pounds of cottonseed meal, 22.7 pounds of corn, less 16.3 pounds of silage and 2.13 pounds of alfalfa hay. In this comparison, 100 pounds of urea pellets #1 was equal in value to 116.8 pounds of cottonseed meal.

Table III Comparison of Urea with Cottonseed Meal in Fattening Steer Calves in Dry Lot (Average of Trial one, 1946-47 and Trial two, 1947-48)

(Average Number of Days Fed, 167)

Lots	I	II	III
Rations	Gr. corn C. S. M. Silage Alfalfa	Gr. corn Urea #1 Silage Alfalfa	Gr. corn Urea #2 Silage Alfalfa
No. steers per lot	20	20[1]	20
Average wt. per steer (lbs.)			
Initial	506	506	506
Final	862	859	868
Gain	365	353	362
Average daily gain	2.14	2.11	2.17
Average daily ration (lbs.)			
Ground corn	11.27	10.82	11.27
Cottonseed meal	1.50	----	----
Urea pellets #1	----	1.50	----
Urea pellets #2	----	----	1.49
Alfalfa hay	1.01	1.02	1.01
Silage	9.49	9.61	9.43
Salt	.02	.02	.015
1-1-1 mineral mixture	.02	.015	.02
Feed per cwt. gain (lbs.)			
Ground corn	527	511	518
Cottonseed meal	70.5	---	---
Urea pellets #1	----	70.5	---
Urea pellets #2	----	---	68.5
Alfalfa hay	47.0	48.5	47.0
Silage	445	456.5	435.5
Salt	1.0	1.0	.8
1-1-1 mineral mixture	.95	.8	.95
Feed cost per cwt. gain (dollars)	24.98	24.63	24.71
Financial result per steer (dollars)			
Apparised value per cwt.	26.75	26.12	26.75
Total value per steer (3% shrink)	223.66	217.63	225.23
Initial cost @ $20.00 per cwt.	101.20	101.20	101.20
Feed cost[2]	88.92	86.94	89.45
Total steer and feed cost	190.12	188.14	190.65
Profit per steer	33.54	29.49	34.58

[1]One steer in lot two was a chronic "bloater" and was removed during trial two. Data of lot two are calculated on the basis of 19 steers.

[2]The feed prices were: Ground corn $3.77 per cwt., cottonseed meal $92.50 per ton, urea pellets #1 and #2 $98.05 per ton, alfalfa hay $23.00 per ton, silage $5.50 per ton, salt $0.88 per cwt., and mineral mixture of equal parts salt, bone meal and ground limestone $2.20 per cwt.

Table IV Chemical Composition of Feeds Used in Table III

	%	Percent Composition of Dry Matter						
	D. M.	Ash	Protein	Fat	Fiber	N.F.E.	Ca	P
Yellow corn	88.78	1.46	8.94	4.25	2.34	83.01	.05	.26
Cottonseed meal	92.18	6.47	41.79	5.23	12.24	34.27	.21	1.23
Atlas sorgo silage	54.42	7.98	3.78	1.93	19.18	67.13	.25	.38
Alfalfa hay	91.93	7.50	14.10	2.63	36.15	39.62	1.18	.30
Urea pellets #1	90.07	6.10	46.69	7.44	9.69	30.08	.37	.66
Urea pellets #2	90.02	5.99	47.26	7.69	8.88	30.18	.50	.62

In the third feeding trial (1948-49) steers that were fed 1.0 pound of urea pellets #2 daily made 0.21 pound less daily gain and required considerably more feed per cwt. of gain than the steers fed an equivalent amount of cottonseed meal. The gains were not significantly different between the two lots according to the F test of Snedecor (1946). One steer of Lot 2 (urea pellets) lost considerable weight during the last month. This weight loss was not considered to have been due to ration but to some other cause. Elimination of this steer showed that the other nine steers made an average daily gain of 2.02 pounds whereas the cottonseed meal steers (Lot 1) gained 2.17 pounds daily. The steer performance in this trial shows that 1.0 pound of supplement containing 50 percent cottonseed meal nitrogen and 50 per cent urea nitrogen when fed with the ration described above was not as satisfactory as 1.0 pound of cottonseed cake.

The average daily gain of the steers of trial four which were fed 1.50 pounds of cottonseed cake (Lot 1), 1.00 pounds of cottonseed cake (Lot 2) and an average of 1.10 pounds of urea pellets #2 (Lot 3) were 2.16, 2.10 and 2.24 pounds, respectively. During the period of the feeding trial when the steers of Lot 3 were fed 1.5 pounds of urea pellets #2, the average daily gain was slightly greater than the gain of those fed 1.5 pounds of cottonseed cake. When the level of urea pellets #2 was lowered to 0.5 pound daily, the steers gained as much daily as those fed 1.5 pounds of cottonseed cake. The differences in average daily gain for the trial among lots was not statistically significant.

The urea fed steers were $1.03 and $7.56 more profitable per steer than the steers of Lots 1 and 2. The appraised price per cwt. for the steers of Lots 1 and 3 was the same but $0.25 greater than the appraised price of the steers of Lot 2. In comparing the feed required to produce 100 pounds of

Table V Comparison of Urea Pellets with Cottonseed Cake in Fattening Steer Calves in Dry Lot (Trial three, 1948-1949)

(Number of Days Fed, 181)

Lots	I	II
Rations	Gr. corn C. S. C. Alfalfa Silage	Gr. corn Urea #2 Alfalfa Silage
No. steers per lot	10	10
Average wt. per steer (lbs.)		
Initial	521	520
Final	914	874
Gain	393	354
Average daily gain	2.17	1.96
Average daily ration (lbs.)		
Ground corn	12.48	11.65
Cottonseed cake	1.00	----
Urea pellets #2	----	.99
Alfalfa hay	1.00	1.00
Silage	6.58	6.54
Salt	.03	.03
1-1-1 mineral mixture	.03	.03
Feed per cwt. gain		
Ground corn	575	596
Cottonseed cake	46	---
Urea pellets #2	--	51
Alfalfa hay	46	51
Silage	304	334
Salt	1	1
1-1-1 mineral mixture	1	1
Feed cost per cwt. gain (dollars)	16.24	19.32
Financial results (dollars)		
Appraised value per cwt.	25.25	25.00
Total value per steer (3% shrink)	223.97	212.00
Initial cost @ $29.50 per cwt.	153.70	153.40
Feed cost[1]	63.84	68.39
Total cost (steer plus feed)	217.54	221.79
Profit per steer	6.43	- 9.79

[1] The feed prices were: Ground corn $2.68 per cwt., Cottonseed cake $86.50 per ton, urea pellets $71.70 per ton, alfalfa hay $20.00 per ton, silage $6.00 per ton, salt $0.73 per cwt., and mineral mixture $1.99 per cwt.

Table VI Chemical Analyses of Feeds Used in 1948-49 Urea Trial

		Percent Composition of Dry Matter						
	% D.M.	Ash	Protein	Fat	Fiber	N.F.E.	Ca	P
Cottonseed cake	92.73	6.01	44.15	7.78	11.46	30.60	.24	.90
Corn	88.22	1.55	10.66	6.43	2.13	79.23	.04	.37
Alfalfa hay	93.49	11.22	19.54	3.12	30.72	35.40	2.27	.14
Silage	40.27	7.15	5.88	2.41	32.88	51.68	.34	.20
Urea pellets	90.22	5.90	53.46	7.49	6.95	26.20	.36	.87

gain between Lots 2 and 3 that received approximately the same amount of protein, 100 pounds of urea pellets replaced 98 pounds of cottonseed cake, 61.2 pounds of corn, 6 pounds of alfalfa, and 45 pounds of silage. These data show that when urea is incorporated into a pellet to provide 50 percent of the nitrogen of the pellet and fed in the manner described above, the gains were as satisfactory as those produced when cottonseed cake was fed as the protein supplement.

Table VII Urea as a Partial Replacement for Cottonseed Meal
(Trial four, 1949-1950)
(Number of Days Fed, 170)

Lots	I	II	III
Rations	Gr. corn C. S. C. Silage Alfalfa	Gr. corn C. S. C. Silage Alfalfa	Gr. corn Urea #2 Silage Alfalfa
Number steers per lot	10[1]	10	10
Average wt. per steer (lbs.)			
Initial	491	491	491
Final	867	848	872
Gain	376	357	381
Average daily gain	2.16	2.10	2.24
Average daily ration (lbs.)			
Ground corn	10.61	11.17	11.25
Cottonseed cake	1.50	1.00	----
Urea pellets #2	-----	----	1.10[2]
Alfalfa hay	1.01	0.99	0.99
Silage	6.3	6.4	6.3
Salt	.06	.05	.04
1-1-1 mineral mixture	.04	.05	.04
Feed per cwt. gain (lbs.)			
Ground corn	492	532	502
Cottonseed cake	70	48	---
Urea pellets #2	--	--	49
Alfalfa hay	47	47	44
Silage	294	303	281
Salt	3	3	2
1-1-1 mineral mixture	2	2	2
Feed cost per cwt. gain (dollars)	15.03	15.67	14.93
Financial results (dollars)			
Appraised value per cwt.	28.00	27.75	28.00
Total value per steer (3% shrink)	235.48	228.38	236.88
Initial cost @ $24.50 per cwt.	120.30	120.30	120.30
Feed cost[3]	56.50	55.93	56.87
Total cost (steer plus feed)	176.80	176.23	177.17
Profit per steer	58.68	52.15	59.71

[1]One steer removed January 11, 1950 because of founder.

[2]Steers of Lot 3 were fed 1.5 pounds of urea pellets for 100 days and 0.5 pounds of urea pellets per steer for 70 days.

[3]The feed prices were: Ground corn $2.38 per cwt., cottonseed cake $67.00 per ton, urea pellets $68.20 per ton, alfalfa hay $20.00 per ton, silage $6.00 per ton, salt $0.52 per cwt., and mineral mixture $1.96 per cwt.

Table VIII Chemical Analyses of Feeds Used in Table VII

	% D. M.	Percent Composition of Dry Matter						
		Ash	Protein	Fat	Fiber	N.F.E.	Ca	P
Corn	87.43	1.71	11.33	5.55	2.22	79.19	.24	.33
Cottonseed cake	93.67	5.93	43.61	6.07	12.49	31.90	.21	.33
Urea pellets	90.52	6.50	48.42	6.53	9.57	28.98	.37	.74
Alfalfa hay	89.68	7.52	16.63	2.72	34.81	38.32	1.07	.33
Silage	32.00	9.22	5.81	2.19	25.19	57.53	.27	.24

SUMMARY

1. Urea incorporated into a protein pellet at levels to provide either 25 or 50 percent of the total nitrogen of the pellet and fed to steer calves at the rate of 1.5 pounds of pellets daily with a corn-silage-alfalfa hay ration satisfactorily replaced cottonseed meal nitrogen.

2. In the trials reported herein, 100 pounds of the urea pellets #1 containing 25 percent urea nitrogen was equal in value to 116.8 pounds of cottonseed meal when fed to fattening steer calves. The replacement value of urea pellets #2 containing 50 percent urea nitrogen was slightly less than that of urea pellets #1. On the basis of prices of feeds fed, 100 pounds of urea pellets #2 was equal in value to 114.4 pounds of cottonseed meal.

3. When 1.0 pound of urea pellets #2 was fed as the protein supplement in a steer fattening ration, the performance of the steer calves was less satisfactory than that of steers fed an equivalent amount of cottonseed meal.

4. When 1.5 pounds of urea pellets #2 were fed as the protein supplement to fattening steer calves during the first 60 percent of the feeding trial and 0.5 pound fed during the remainder of the trial, the performance of the steer calves was more satisfactory than that of steers fed either 1.5 or 1.0 pounds of cottonseed cake during the entire trial.

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PART III LEVELS OF PROTEIN

Review of Literature

It is highly important in fattening cattle to know definitely how much protein supplement should be added to the ration. Since protein supplements ordinarily cost more per ton than grain, the profits will be materially reduced if animals are fed larger amounts of supplement than are actually needed. Morrison (1948) states "numerous experiements have proved that fattening cattle and other beef cattle do not need nearly so much protein as was recommended by older feeding standards."

McCampbell (1925) fed varying amounts of cottonseed meal in a steer fattening ration composed of silage, alfalfa hay and corn. In two experiments his data indicated that adding 1 pound of cottonseed meal per head was more profitable than adding two pounds.

Blizzard (1928) conducted an experiement to determine the amount of cottonseed meal that could be fed safely and profitably in fattening rations of calves. The basal ration consisted of ground corn, cottonseed meal and ground limestone. When the cottonseed meal was fed at the rate of 1.28, 2.01 and 2.77 pounds per head daily the steers fed 1.28 pounds of meal per head per day made the greatest and most economical gains. Oklahome workers reported in the Biennial Report (1932-1934) further studies of profitable levels of cottonseed meal to feed calves. Rations consisting of corn and prairie hay supplemented with 1.30, 2.46 and 3.50 pounds of cottonseed meal were fed weanling steer calves. The lot of steers fed the ration supplemented with 2.46 pounds of cottonseed meal, made slightly greater daily gains than the steers of the other two lots. The steers that were fed 1.30 pounds of cottonseed meal made the cheapest gains. Three lots of steers were compared in the 1933-1934 feeding trial. The

average daily rations fed and the average daily gains were as follows:

Average daily ration	Lot 1	Lot 2	Lot 3
Ground Corn	7.70	6.69	5.90
Cottonseed meal	1.54	2.36	3.50
Prairie Hay	2.27	2.30	2.45
Kafir silage	6.64	6.93	6.64
Gr. Limestone	.19	.18	.19
Nutritive ratio	6.9	5.7	4.6
Average daily gain	1.96	1.99	1.99

The steers of Lot 2 made the cheapest gains. The Lot 3 steers made the same average daily gain as the steers of Lot 2, but the extra cottonseed meal added to the cost. The steers in Lot 1, fed 1.54 pounds of cottonseed meal per head daily, made practically the same gains as the other two lots, but the Lot 2 steers that were fed 2.36 pounds of cottonseed meal were the most profitable.

Experiments to determine the amount of protein to feed beef calves, were conducted by Gerlaugh(1938). He found that 1.6 pounds of a protein supplement containing 45 percent crude protein was a safe amount to feed. Two and four-tenths pounds of the same supplement produced fatter calves quicker, but at a greater cost.

Morrison (1940) recommended that rations for fattening calves should have nutritive ratios not wider than 1:6.5 to 1:7.3; for yearlings, not wider than 1:7.0 to 1:8.0; and for 2-year-olds, not wider than 1:7.5 to 1:8.5. When the rations contain less protein than provided by these nutritive ratios, Morrison, (1940) states "the gains will usually be considerably less rapid, and more feed will be required per 100 pounds gain."

Cottonseed meal is often cheaper per ton in the south than many other concentrates, and feeders desire to make the maximum use of it. When it was used in larger amounts than was necessary to balance the ration of steer calves Blizzard and Taylor (1938, 1939) reported that it may be worth slight-

ly more per pound than yellow corn as a fattening concentrate. Knox (1939) found that a full feed of cottonseed meal gave more gain than one-half meal and one-half ground kafir when fed with corn silage and alfalfa hay to fattening cattle. Blizzard and Taylor (1940) made a comparison of ground shelled corn and cottonseed cake in steer fattening rations. Their results indicated that 43 percent cottonseed cake replaced at least 50 percent of the corn without reducing the efficiency of the ration when an adequate source of vitamin A was provided. They found that this substitution can be considered when the cake sells at the same or lower price per pound than corn. Taylor (1940) substituted 43 percent cottonseed cake for part of the ground shelled corn in a calf fattening ration of ground oats, ground shelled corn, cottonseed cake, silage and ground limestone. Two lots of steers were compared. The steers of Lot 1 were full fed corn and received 1.99 pounds of cake per head daily. The steers of Lot 2 were also fed 1.99 pounds of cottonseed cake per head daily, but 3.61 pounds of cottonseed cake were fed in addition, replacing 4.49 pounds of corn in the ration. In the production of 100 pounds of gain 182 pounds of 43 percent cottonseed cake replaced 210 pounds of corn, but required an additional 10 pounds of oats and 14 pounds of silage. Both lots of steers gained slightly over 2 pounds per head daily, but the steers full fed corn produced 100 pounds of gain at $1.24 less cost than those fed the larger amount of cottonseed meal.

Means (1945) reported weanling calves can be fed all the cottonseed meal or cake they will eat for 140 to 150 days with no injurious effect, provided that 3 pounds of good legume hay is included in the ration. He fed two lots of steers 8 pounds of cottonseed cake or meal plus corn, fed ad libitum, and obtained satisfactory gains and profits.

Morrison (1940) cites the results of several experiments with alfalfa hay included in the fattening ration. He concluded it does not usually pay to add a protein supplement to corn and a liberal feed of good alfalfa hay for 2-year-old and yearling beef steers. If the amount of alfalfa hay is decreased some from liberal feeding, it will require only a small amount of protein supplement to balance the ration.

Several investigations have been made on the affect of levels of protein on the net energy value of a ration. Mitchell, et al. (1940) found that the utilization of the metabolizable energy in the ration of the calf was not impaired by inadequate levels of protein within the limits of 6 percent and 20 percent tested. Maynard (1947) states "there is evidence that the more nearly balanced the ration the smaller the proportion of it which is dissipated as heat and the greater, therefore, is its net energy value."

There are many references to feeds which show a general depression in dry matter digestibility with low levels of protein feeding. Maynard (1947), and Morrison (1948) have reported the influence of protein upon ration digestibility in cattle. Burroughs, Wise and Gerlaugh (1949) reported that the addition of soybean oil meal to a low protein ration for fattening cattle increased the dry matter digestibility of corn cobs and timothy hay 14 and 17 percent respectively. Four rations were used, one with and one without corn cobs at an 8 percent protein level, and one ration with and without corn cobs at a 15 percent protein level. Burroughs, et al. (1949), in further observations on the effect of protein upon roughage digestion in cattle, varied the protein levels by substituting dried skim milk for mineralized starch in three trials. Their conclusion was that the protein requirement for efficient roughage digestion in cattle is extremely low when roughages are fed in the absence of starch or starchy grains. When starch was

added to the ration, the need for the protein supplement, dried skim milk, was increased.

Burroughs, et al. (1940) stated that protein fed to cattle and other ruminants presumably serves two separate physiological functions. One function pertains to the growth and development of micro-organisms in the digestive tract in fostering roughage digestion and synthesis of B-vitamins and amino acids. The other relates to the growth of the body. The total minimum protein requirement of cattle for the maximum production depends upon which functional need for protein is the greatest, since the feed protein is used in both functions.

EXPERIMENTAL

Previous experimental work at this station has shown that a ration of corn, sorghum silage, alfalfa hay, salt and minerals supplemented with 1.5 pounds of cottonseed meal produced satisfactory gain and finish when fed to weanling steer calves. The urea experiments reported in Part II of this paper suggested that equally as good performance could be secured when such a ration was supplemented with less cottonseed meal.

To determine the optimum level of protein to add to a ration of corn, sorghum silage, alfalfa hay, salt and minerals, an experiment was initiated in the fall of 1948 to study this problem. Three lots of 10 weanling Hereford steer calves each were fed the following rations:

	Lot 1	Lot 2	Lot 3
Ground yellow corn	Full fed	Full fed	Full fed
Sorghum silage	Limited	Limited	Limited
Alfalfa hay	1.0 pound	1.0 pound	1.0 pound
Cottonseed cake	1.5 pound	1.0 pound	0.5 pound
Salt	Free choice	Free choice	Free choice
1-1-1 mineral mixture	Free choice	Free choice	Free choice

The results of two trials are reported in this paper.

The silage fed during the 1948-49 trial was Atlas Sorgo, and during the 1949-50 trial it was Honey Drip.

RESULTS AND DISCUSSION

The average data for the two trials are presented in Table IX. The average daily gain for the steers supplemented with 1.5, 1.0 and 0.5 pound of cottonseed cake was 2.12, 2.14 and 2.07 pounds, respectively. The differences were not statistically significant. Although the steers fed the ration supplemented with 0.5 pound of cottonseed cake (Lot 3) required somewhat more corn per cwt. gain than either of the other two lots, considerably

less cottonseed cake was required, resulting in the lowest cost per 100 pounds gain of the three lots. The steers fed the ration supplemented with 1.0 pounds of cottonseed cake (Lot 2) required slightly more corn per cwt. gain than those supplemented with 1.5 pounds of cottonseed cake (Lot 1), but the total cost per cwt. gain was slightly less due to the lower requirement of cottonseed cake.

The steers fed 1.5 pounds of cottonseed cake were slightly fatter than the other two lots as indicated by the higher appraised price per cwt. The steers of Lot 2 were appraised at $0.25 per cwt. higher than the steers of Lot 3.

The returns per steer for Lots 1, 2 and 3 were $25.03, $25.23 and $23.68, respectively.

The nutritive ratios for the average daily rations of the steers fed 1.5, 1.0 and 0.5 pounds of cottonseed cake were 1:6.3, 1:7.2 and 1:8.2, respectively. Morrison (1948) recommends nutritive ratios of 1:6.6 to 1:7.3 for calves being fattened for baby beef between the weights of 500 and 900 pounds. The nutritive ratio of the ration containing 1.5 pounds of cottonseed cake was too narrow, and that of the ration containing 0.5 pound of cottonseed cake was slightly too wide according to Morrison's standards. Morrison (1948) also recommended a minimum of 1.3 to 1.75 pounds of digestible protein in the daily ration for fattening steers weighing 600 and 900 pounds that gain an average of 2.0 pounds daily per steer. The calculated daily digestible protein intake for the steers of Lots 1, 2 and 3 in this study were 1.35, 1.21 and 1.03 pounds, respectively. On the basis of these trials it would appear that the daily digestible protein intakes recommended by Morrison are somewhat too high for steers weighing 500 to 850 pounds.

Although levels of protein supplements from 1 pound to 5 pounds or more

Table IX Levels of Cottonseed Cake
(Average of Trial One, 1948-49 and Trial Two, 1949-50)

(Average Number of Days Fed, 176)

Lots	I Gr. corn C. S. C. Silage Alfalfa	II Gr. corn C. S. C. Silage Alfalfa	III Gr. corn C. S. C. Silage Alfalfa
Number of steers per lot	20[1]	20	20
Average wt. per steer (lbs.)			
Initial	506	506	506
Final	882	881	868
Gain	376	375	362
Average daily gain	2.12	2.14	2.07
Average daily ration (lbs.)			
Ground corn	11.19	11.82	11.72
Cottonseed cake	1.50	1.00	.51
Alfalfa hay	1.01	1.00	.99
Silage	6.45	6.49	6.43
Salt	.05	.04	.04
1-1-1 mineral mixture	.04	.04	.04
Feed per cwt. gain (lbs.)			
Ground corn	530	554	567
Cottonseed cake	71	47	25
Alfalfa hay	47.5	46.5	48
Silage	306	304	311
Salt	2	2	1.5
1-1-1 mineral mixture	1.5	1.5	1.5
Feed cost per cwt. gain (dollars)	17.58	17.26	16.77
Financial results (dollars)			
Appraised value per cwt.	26.62	26.50	26.25
Total value per steer (3% shrink)	227.86	226.58	221.02
Initial cost @ $27.00 per cwt.	136.62	136.62	136.62
Feed cost[2]	66.21	64.73	60.71
Total cost (steer plus feed)	202.83	201.35	197.34
Profit per steer	25.03	25.23	23.68

[1]One steer was removed in trial 2 on January 11, 1950 because of founder.

[2]The feed prices were: Ground corn $2.53 per cwt., cottonseed cake $76.75 per ton, alfalfa hay $21.00 per ton, silage $6.00 per ton, salt $0.63 per cwt., and mineral mixture $1.97 per cwt.

Table X Chemical Analyses of Feeds for Table IX

	% D.M.	Percent Composition of Dry Matter							
		Ash	Protein	Fat	Fiber	N.F.E.	Ca	P	Carotene[1]
Corn	87.82	1.63	11.00	5.99	2.18	79.20	.14	.35	1
Cottonseed cake	93.20	5.97	43.88	6.92	11.98	31.25	.22	.84	
Alfalfa hay	91.58	9.37	18.08	2.92	32.76	36.87	1.67	.24	20
Silage	36.14	8.18	5.84	2.30	29.04	54.64	.30	.22	5

[1]Parts per million

have proven satisfactory in fattening steer rations by various investigators, the more profitable gains of the lot 2 steers from the results of these two trials indicate that 1.0 pound of cottonseed cake would be more satisfactory with this type of ration at present feed prices. These results agree with those obtained by McCampbell (1925) and Blizzard (1928) who found that 1.0 and 1.28 pounds of cottonseed cake made the largest and most economical gains. They fed rations similar to the ones fed in these two trials, except that no silage was fed in the trial reported by Blizzard.

SUMMARY

Under the conditions of these trials a steer calf fattening ration of corn, sorghum silage, alfalfa hay, salt and mineral supplemented with 1.0 pound of cottonseed cake produced more satisfactory results than when supplemented with either 1.5 or 0.5 pounds of cottonseed cake. Although the steers fed the ration supplemented with 1.0 pound of cottonseed cake were not quite as fat as those fed 1.5 pounds of cottonseed cake, the greater gain and lower feed cost resulted in slightly more profit per steer.

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PART IV CAROTENE

Review of Literature

Moore (1929) produced proof that the animal body transformed carotene into vitamin A. The principal source of this vitamin is the carotene or yellow pigment found in all green plant tissues.

Guilbert and Hart (1935) found that the daily minimum requirements of carotene for cattle weighing 130 to 500 Kg., to be 26 to 33 mcg. per kilogram of body weight. Jones, et al. (1938) reported a slightly higher requirement for fattening beef cattle.

Vitamin A is the vitamin of greatest practical importance for beef cattle, according to Ohio workers (1938). Guilbert and Rochford (1940) stated that the only vitamins definitely required in the dietary of the bovine were A and D. A prolonged deficiency of vitamin A resulted in lower gains, less efficient use of feeds, more sick animals, greater mortality, a lower grade of finished animal and night blindness, according to Jones, et al. (1938), Wall (1940), Kemmerer, Fudge and Fraps (1942)

Kemmerer, et al.(1942) reported that 4 parts per million (36 mg. in 20 lbs. of feed) of carotene may be needed in dry range forage for cattle. They indicated, however, that a level as low as 1.7 p. p. m. would be sufficient in green feeds. These Texas workers reported that the carotene requirements of cattle are lowest at maintenance or when growing cattle are being fattened. Under these conditions Jones, et al.(1938) found that 1500 micrograms per 100 pounds of live weight appeared to be sufficient to sustain health and produce good growth, but this amount was not sufficient to prevent night blindness. In a later study Jones, et al.(1941) depleted 50 fattening beef steer calves of their vitamin A reserves and supplemented

the ration with 1250, 1500, 2500, 3000 and 5000 micrograms of carotene in the form of alfalfa leaf meal per 100 lbs. live weight daily during a 140 day fattening period. There was no significant difference in gain, carcass weight or carcass grade among the groups.

Lewis and Wilson (1944) reported an experiment with six groups of four calves each, that were fed various levels of vitamin A, ranging from 32 to 1024 U. S. P. units per kilogram of body weight per day. These levels were fed for a period of four to eight months. Data were obtained on rate of growth, blood levels of vitamin A and liver storage. The results indicated that maximum growth was obtained on an intake of 64 U. S. P. units per kilogram of body weight. The concentration of vitamin A in the blood reached maximum levels at an intake of 512 U. S. P. units per kilogram of body weight. Liver stores were quite variable. In general the calves receiving 512 units per kilogram or below had quite low liver stores, while those receiving 1024 units per kilogram of body weight had considerable storage.

A recent report of the committee of Animal Nutrition of the National Research Council (1945) recommended 5.5 mg. of carotene per 100 lbs. live weight per day for beef cattle. The committee stated that 1.4 to 1.6 mg. of carotene per 100 lbs. live weight proved adequate for normal beef cattle growth.

Hoefer, Gallup, and Hillier (1946) stated that vitamin A deficiency symptoms may require from 30 to 200 or more days to appear in sheep or cattle. Jones, et al.(1938) reported that short yearlings required an average of 142 days on a carotene deficient diet to deplete their previous storage of carotene to a degree sufficient to exhibit deficiency symptoms. Hoefer, et al.(1946) found that cattle have the ability to store great quantities

of vitamin A and carotene during periods of high intake. They mentioned the inability to see in dim light as an early indication of vitamin A deficiency. Hoefer, et al. (1946), in referring to night blindness, stated "this symptom is one of the first to be observed in fattening cattle fed for extended periods on rations containing a high proportion of grain and a limited amount of low grade roughage."

Fraps (1947) stated that deficiency of vitamin A in range animals or fattening cattle may be expected only under rather extreme conditions or prolonged drouth, or after long periods of fattening in the dry lot when the roughage used contains little or no carotene. He recommended feeding 2 mg. of carotene per 100 pounds of live weight daily as a sufficient amount to prevent serious conditions of vitamin deficiency in usual fattening periods for steers, but suggested that 1.5 mg. might be adequate.

Rosenberg (1945), Maynard (1947) and Chornock (1948) have reviewed the physiological function and symptoms of deficiency of vitamin A and its precursor, carotene.

Newman (1948) stated "two units or more of carotene are required to give results equal to one unit of true vitamin A". Koehn (1948) confirms this. He determined the relative biological potencies of pure vitamin A alcohol, vitamin A acetate and beta-carotene under identical dietary conditions. The results showed that beta-carotene and vitamin A alcohol had equal activities on the weight basis.

Mattson (1948) presented two years investigations that showed one site of conversion of carotene to vitamin A in the rat was the intestinal wall. His work indicated that vitamin A was present in the intestinal wall of rats 4 hours after supplementing with carotene by a stomach tube.

Elliot (1949) presented evidence in support of the view that the

intestional wall is a site of conversion of carotene to vitamin A in dairy calves. No positive evidence was obtained to show that carotene in blood plasma is converted to vitamin A in either the Guernsey or Holstein calf.

Van Arsdell (1948) gave a very good review of literature on carotene and vitamin A and its effect upon the blood constituents of cows and calves. He gave an extensive review of the dairy cattle work on the importance of carotene in the late stages of parturition and for the young calf.

Newman (1948) cited several factors which might influence vitamin A utilization in cattle. An unhealthy condition, such as digestive disturbances in a calf, either interferes with carotene absorption or increases the animals requirements for vitamin A. Carotene in low-carotene roughages, as compared to high-carotene roughages, was thought to be less available or in less biologically active chemical forms. He reported that vitamin E or factors associated with it, stabilized carotene or vitamin A in the ration. Some materials such as raw soybeans or rancid fats, when present in a ration, were found to interfere with a maximum utilization of carotene and vitamin A.

Baker, Loeffel and Hansen (1947) reported trials supplementing cattle rations with carotene. Thirty steer calves were fed vitamin A-deficient rations for 70 days. They were then divided into three uniform lots and were full fed ground Early Kalo, 4.0 pounds of chopped alfalfa hay (brown hay very low in carotene) and 0.5 pound of soybean oil meal per head daily. Two lots were fed carotene supplements of 10 to 14 mcg. and 30 mcg. of carotene per head daily for 210 and 280 days respectively. The lots fed carotene consumed more grain and made greater average daily gains than those not fed carotene. Clinical deficiency symptoms generally were not as pronounced in this trial as in previous trials in the deficient carotene ration group. More difficulty was experienced with urinary calculi, however.

Tom (1947), emphasizing vitamin A needs for range livestock reported uniformly satisfactory results with a practical vitamin A carrier during more than 3 years of repeated experiments under controlled conditions. One group of experiments conducted under practical range conditions during the winter period of 1946-1947 resulted in 41 pounds more gain for each cow and 17 pounds more for her calf (approximately 6 weeks old) when a supplement fortified with vitamin A was fed and compared with a standard high protein supplement.

Madsen and Earle (1948) confirmed previous reports on the relation of vitamin A deficiency to the development of edema or anasarca in cattle. They reported symptoms of typical avitaminosis-A of cattle. Observations were made on 41 yearling Hereford steers that were fattening for over a year mostly on corn and fodder with 1 pound of molasses and alfalfa supplement from November to June. The cattle did not have access to pasture during the summer. One symptom observed was loss of appetite. Appetite was restored by feeding alfalfa hay. In September, oat straw was substituted for the alfalfa. By December, 30 of the steers had swollen legs and enlarged briskets. Replacement of the oat straw with alfalfa brought about marked improvement in two weeks and nearly complete recovery in seven weeks. Madsen and Earle (1948) were able to duplicate these symptoms, experimentally, with diets either deficient or low in carotene.

Stephens, et al. (1948) reported a wintering trial with two-year-old steers fed a carotene carrier. Their data indicate dry range grasses supplemented with a protein feed containing 27 percent crude protein and 35 parts per million of carotene, when fed at about the same energy equivalent level as the other protein supplements, was superior to cottonseed cake and urea pellets, but failed to produce as much gain as soybean pellets.

Ross, Watts and Darlow (1949) obtained additional information in supplementing beef cattle rations with carotene in a wintering trial under range conditions. The yearling and weanling heifers fed the carotene fortified pellets made slightly more gain than those fed cottonseed cake. The reverse was true in the steer trials. The carotene-cottonseed meal pellet was made by mixing a crude carotene concentrate made from alfalfa with cottonseed meal and pelleting the mixture. The carotene potency was so adjusted that 2.5 pounds of the pellet contained approximately 20 mg. of beta-carotene. Although the weanling heifer calves fed only cottonseed cake had dangerously low plasma carotene levels in January and February, the vitamin A level was within an accepted range for good health. There was no difference in health or vigor among the various lots.

Ross and Gallup (1949), in vitamin A deficient studies with beef cattle on phosphorus deficient rations, secured data which indicated an inverse relationship between the level of plasma inorganic phosphorus and plasma carotene content. The level of plasma carotene averaged 20 percent higher in the unsupplemented lot than in the phosphorus supplemented lot.

Experimental

Although a ration of ground yellow corn, Atlas Sorgo silage, 1.0 pound of alfalfa hay, salt and minerals when fed to steer calves has not produced any symptoms of vitamin A deficiency, it appeared possible that additional carotene might stimulate gain. To test this hypothesis, an experiment was initiated in the fall of 1948 to determine the value of adding carotene to a ration such as that outlined above. Two lots of weanling Hereford steer calves were fed the following ration: ground yellow corn, full fed; sorghum silage, limited to insure maximum consumption of corn; 1.0 pound of alfalfa hay; and salt and mineral, free choice. The ration fed the steers of Lot 1 was supplemented with 1.5 pounds of cottonseed cake, and the ration fed the steers of Lot 2 was supplemented with 1.5 pounds of a pelleted feed containing cottonseed meal and crude carotene concentrate. The crude carotene was made from alfalfa by the Valley Vitamins, Inc., of McAllen, Texas. During the 1948-49 trial each pound of pellets contained 7.8 milligrams of beta-carotene and during the 1949-50 trial each pound of pellets contained 14.3 milligrams of beta-carotene. Atlas sorghum silage was fed during the first trial and Honey Drip sorghum silage was fed during the second trial.

Results and Discussion

The data from the two trials were averaged and are presented in Table XI. The chemical composition of the feeds fed are presented in Table XII. The data obtained from the first trial suggested that it might be advantageous to feed additional carotene to fattening calves. The steers of Lot 2, which were fed 1.5 pounds of the carotene-cottonseed meal pellets per steer per day, gained 0.18 pound more than the steers of Lot 1 that were fed 1.5

Table XI Determination of Value of Additional Carotene
(Average of Trial One, 1948-49 and Trial Two, 1949-50)

(Average Number of Days Fed, 176)

Lot	I Gr. corn C. S. C. Silage Alfalfa	II Gr. corn Carotene pellets [1] Silage Alfalfa
Number of steers per lot	20[2]	20
Average wt. per steer (lbs.)		
Initial	506	505
Final	882	894
Gain	376	389
Average daily gain	2.12	2.22
Average daily ration (lbs.)		
Ground corn	11.19	11.83
Cottonseed cake	1.50	-----
Carotene pellets	-----	1.50
Alfalfa hay	1.01	1.00
Silage	6.4	6.4
Salt	.05	.04
1-1-1 mineral mixture	.04	.03
Feed per cwt. gain (lbs.)		
Ground corn	531	534
Cottonseed cake	71	----
Carotene pellets	--	68
Alfalfa hay	47	45
Silage	306	292
Salt	2	2
1-1-1 mineral mixture	2	2
Feed cost per cwt. gain	17.61	17.97
Financial results (dollars)		
Appraised value per cwt.	26.62	26.62
Total value per steer (3% shrink)	227.86	230.79
Initial cost @ $27.00 per cwt.	136.62	136.35
Feed cost[3]	66.21	69.90
Total cost (steer plus feed)	202.83	206.25
Profit per steer	25.03	24.54

[1] Cottonseed cake carotene pellets contain 11.0 mg. of carotene per pound.

[2] One steer was removed during trial Jan. 11, 1950 because of founder.

[3] The prices of the feed fed were: Corn, $2.53 per cwt.; Cottonseed cake, $76.75 per ton; carotene pellets, $90.00 per ton; alfalfa hay, $21.00 per ton; silage, $6.00 per ton; salt, $0.63 per cwt.; and mineral mixture, $1.97 per cwt.

Table XII Chemical Composition of Feeds used in Table XI

	% D.M.	Percent Composition of Dry Matter							
		Ash	Protein	Fat	Fiber	N.F.E.	Ca	P	Carotene[1]
Corn	87.82	1.63	11.00	5.99	2.18	79.20	.14	.35	1
Cottonseed cake	93.20	5.97	43.88	6.92	11.98	31.25	.22	.84	
Carotene pellets	92.17	5.72	42.14	7.75	10.84	33.55	.37	.93	26
Alfalfa hay	91.58	9.37	18.08	2.92	32.76	36.87	1.67	.24	20
Silage	36.14	8.18	5.84	2.30	29.04	54.64	.30	.22	5

[1] Parts per million

pounds of cottonseed cake per steer per day. The carotene supplemented steers were also $5.95 more profitable per steer.

Both lots of steers gained at approximately the same rate during the 1949-1950 trial, but the straight cottonseed cake supplemented steers were $7.87 more profitable per steer.

The summary of the data obtained in both trials show that the steers fed 1.5 pounds of the carotene pellets per head daily made an average daily gain of 2.22 pounds and those fed cottonseed cake gained 2.12 pounds daily. The feed cost per cwt. gain was $0.36 higher, however, for the carotene supplemented steers than for those fed straight cottonseed cake. Most of the extra feed cost was due to the high cost of the carotene which was added to the cottonseed meal to make the pellets.

The profits per steer were $25.03 and $24.54, for Lots 1 and 2, respectively.

Summary

The data of a two year study in which additional carotene was fed with a ration of yellow corn, sorghum silage, 1.0 pound of alfalfa hay, salt and mineral showed no consistent advantage for fattening steer calves when compared to the same ration without the added carotene.

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