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The Use of

UREA and STILBESTROL

In Rations for

BEEF CATTLE

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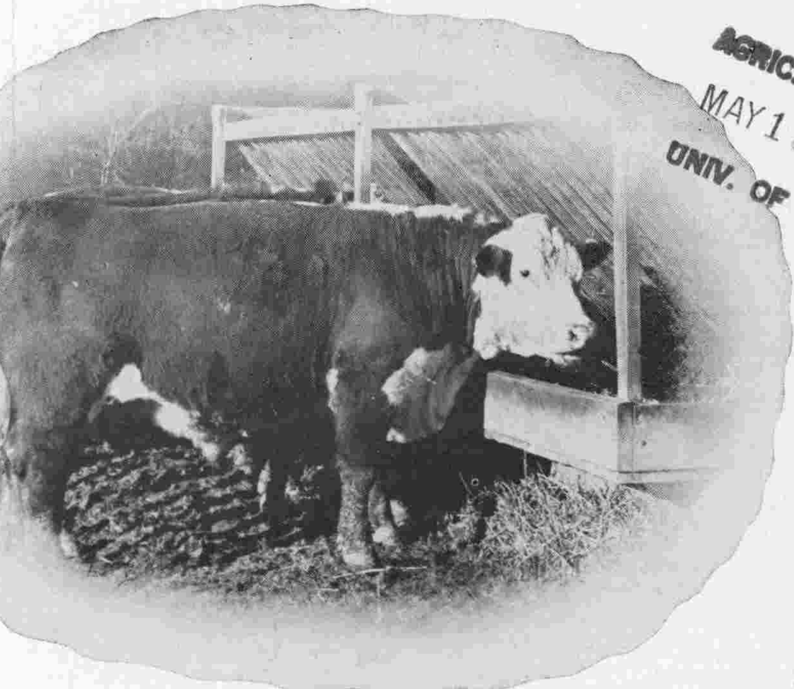

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SUMMARY

• These beef cattle experiments, conducted at Knoxville, Oak Ridge, and Crossville, involved fattening studies and cattle wintering studies comparing protein supplements and roughages.

• In the steer fattening experiments, two separate trials—using 62 yearling steers—were conducted to evaluate the substitution of urea and corn with and without stilbestrol for part or all of the protein supplement needed to balance a low protein fattening ration. Treatments were the same for both trials and were as follows: 1, cottonseed meal; 2, 50 percent cottonseed meal and 50 percent urea; 3, urea; 4, urea plus stilbestrol.

• The average daily gains in the first trial were 2.05, 2.12, 1.76, and 2.11 lb. for the steers on supplements of 1, 2, 3, and 4, respectively. Average daily gains in the second trial were 2.08, 2.17, 2.08, and 2.53 lb. per steer on supplements 1, 2, 3, and 4. In the second trial, steers fed supplement 4 made a highly significant greater daily gain over all other lots of steers.

• Adding stilbestrol resulted in a feed saving of about 11 percent in the first trial and about 17 percent in the second. Carcass grades and dressing percentages were similar for all treatments in both trials. A statistically significant difference in percent shrink from feed-lot to market was found in the second trial favoring treatment 1 over treatments 2 and 4.

• These results show that urea and corn can substitute for 50 percent of the cottonseed meal needed to supplement fattening rations for steers. Also, under some conditions, urea and corn may replace all the cottonseed meal. Oral administration of stilbestrol increased both rate of gain and feed efficiency when added to a ration in which urea was substituted for all the natural protein supplement.

• Wintering studies using 302 heifer and steer calves showed that there were large differences in gain from feeding different roughages. Corn silage and hay produced significantly greater and much cheaper gains than hay alone. In the wintering studies using 48 beef cows on oat straw and grass hay, there were no significant differences in performance of cows fed either cottonseed meal, urea supplement, or Purdue Supplement A.

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THE USE OF UREA AND STILBESTROL IN RATIONS FOR BEEF CATTLE[1]

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INTRODUCTION AND REVIEW OF LITERATURE

Protein Needs for Livestock.—In making maximum use of home grown feeds, protein is the nutrient most likely to be lacking in rations for farm livestock. Most roughages used for wintering-fattening ruminants do not contain enough protein for economical and efficient production.

All animal and vegetable cells contain protein as an essential constituent. This protein is manufactured in plants while animals must be fed protein since they do not have the power to synthesize protein as plants do. Animals can use amino acids, which are the building blocks of protein, to form protein needed in the vital processes in the animal body. Protein is needed in rations for all animals—not only for normal growth, reproduction and lactation—but also to take care of the wear and tear on body tissues known as maintenance.

Farm animals vary in their ability to manufacture the amino acids needed for body processes. Swine and poultry need rations containing the essential amino acids, while ruminants such as cattle and sheep are able to manufacture part of the needed amino acids by the action of the billions of microorganisms present in the rumen. And when there are shortages of natural protein supplements, there is a definite need for protein substitutes.

Urea. Urea is a protein substitute that has been used successfully to replace a part of natural protein supplements for cattle and sheep. Chemically, urea is a diamide of carbonic acid and is the principal end product of protein metabolism in mammals, being

[1] The authors of this bulletin gratefully acknowledge the contributions to these experiments and to the preparation of this manuscript by C. S. Hobbs, head of the University of Tennessee Animal Husbandry-Veterinary Science Department, and by R. L. Murphree, animal husbandman and Acting Director of the University of Tennessee-Atomic Energy Commission Agricultural Research Programs.

thus found in the urine of all four-legged farm animals and also man. Urea is manufactured commercially and, for feeding purposes, is normally standardized to 42 percent nitrogen. This is equivalent to 262 percent crude protein, since protein is commonly calculated by multiplying the nitrogen content of a feedstuff by the factor 6.25.

Armsby (1911) showed that ruminants could utilize non-protein nitrogen to a limited extent; however, it was not until recent years that urea has come into widespread use as a protein substitute. This has been brought about as a result of extensive experimental work along with the need for protein substitutes to relieve shortages. Reid (1953) in an extensive review article has covered most of the research work on urea as a livestock feed.

Hunt **et al.** (1954), and Jordan (1953) have generally shown that, for microorganisms to make efficient conversion of urea to protein, the ration fed must contain readily available carbohydrates and some protein as such. These workers found that poor conversion of urea occurs when it is added to hay rations without concentrates.

Gallup **et al.** (1953) in an 8-year study showed that pellets in which urea supplied the equivalent of either 25 or 50 percent of the protein produced gains equal to those produced by the common plant protein supplements for fattening calves. Pellets with 85 percent of the nitrogen supplied by urea were in general unsatisfactory. Culbertson **et al.** (1951) found urea to be equal to soybean oil meal in replacing all the soybean oil meal needed to balance a fattening ration made up of shelled corn and mixed hay for yearling steers.

In metabolism tests, low protein roughages such as grass hay and cottonseed hulls were not found to be efficiently supplemented with urea alone as shown by Gallup **et al.** (1953). Much of the urea was wasted unless some carbohydrate such as a cereal grain was added. Bell **et al.** (1953), using a series of digestion and nitrogen balance studies, found that urea nitrogen had very little effect on apparent digestibility of nutrients with the exception of protein digestion which was increased in all rations. The addition of urea also was found to improve nitrogen retention significantly in all cases.

Gallup **et al.** (1953) suggest that urea may produce harmful effects under certain conditions, such as rapid consumption of urea-containing feeds by starved animals or by animals not having previously been fed feeds containing urea. However, urea toxicity would not be expected in animals that are accustomed to properly mixed rations containing urea at the recommended levels. Dowe (1953) stated that since urea can be toxic, it is recommended to limit urea to 1 percent by weight of the total dry matter intake. However, Bell (1957) recommended that urea not exceed 1.5 percent of the total ration. The Association of American Feed Control Officials (Dowe, 1953) has recommended that mixtures carrying more than 3 percent urea be labeled with appropriate feeding instructions.

Green (1955) states that hundreds of thousands of tons of ruminant feeds containing urea are being fed successfully each year in the United States, and that this practice may be expected to increase in the future. Urea is of no value to swine and poultry, but the practice of feeding urea to ruminants makes more natural protein available at lower cost for swine and poultry.

Stilbestrol. Stilbestrol is a synthetic compound with estrogenic properties which is capable of producing many of the effects brought on by the female hormone estradiol. Small amounts of stilbestrol administered either orally or as a subcutaneous implant have been shown to increase both rate of gain and feed efficiency in cattle and sheep.

Andrews **et al.** (1954) and O'Mary **et al.** (1956) have demonstrated increased rate of gain and feed efficiency by implanting stilbestrol pellets subcutaneously in feeder steers. Since 1954, many reports such as those by Burroughs **et al.** (1954a and 1954b), Perry **et al.** (1955), and Murphree (1955) have shown increased rate of gain and feed efficiency by oral administration of stilbestrol at levels of 5 and 10 milligrams per day to fattening steers. Clegg and Cole (1954) and Goetsch (1955) agree that the mode of action of stilbestrol is still vague. However, they suggest that stilbestrol may increase weight gains and feed efficiency by its effect on the pituitary and adrenal glands, since these glands were found to be significantly larger in treated animals. Stilbestrol implants have been shown to increase the retention of nitrogen, calcium, and phosphorus in lambs, (Whitehair **et al.** 1953). Bell **et al.** (1955) reported significantly greater retention of nitrogen, calcium and phosphorus in lambs due to stilbestrol feeding. No effects were noted on ration digestibility.

Burroughs **et al.** (1954a) and Culbertson **et al.** (1955) showed response to stilbestrol feeding to beef cattle for over 200 days.

Murphree (1955) and Beeson **et al.** (1956) found the length of beneficial use to be approximately 100 days for oral administration of stilbestrol in the case of fattening steers, and O'Mary and Cullison (1956) have shown significant benefit from pellet implantation for a similar period. Burroughs **et al.** (1954a) lists the advantages of stilbestrol over pellet implantation as: "reduction of labor and technology required for the restraint of animals for pellet implantation and better control of the levels administered." However, stilbestrol implants are less expensive and do not require a commercially mixed feed. More research is needed to compare implants with feeding of stilbestrol and also to determine the length of time in which a response will be obtained from stilbestrol. Stilbestrol, like urea, has not been shown to benefit swine, but when used in ruminant feeding, it may extend the total supply of feed and thus help lower the cost of producing swine and poultry.

These investigations were conducted with the following objectives: (1) to study the substitution of urea and corn, on a nitrogen basis, for part or all of the protein supplement needed to balance a low-protein fattening ration for steers; (2) to study the effect of adding 10 milligrams of stilbestrol per steer daily to a ration in which urea was used as the sole protein supplement in balancing the fattening rations; (3) to compare urea with cottonseed meal and Purdue supplement A as protein supplements for wintering beef calves and beef cows; and (4) to compare protein supplements when fed with an all-hay ration and when fed with a corn silage and hay ration.

When these experiments were started, there was information on the substitution of urea for cottonseed meal under conditions in other parts of the United States. However, no information was available on the use of stilbestrol in combination with urea for fattening cattle. This bulletin describes the first of a series of experiments in which stilbestrol was used in rations for fattening cattle at the Tennessee Experimental station. Before these wintering studies were conducted, most feed manufacturers had been using 5 percent or less urea in protein supplements. Generally it had been assumed that above this level, toxicity or poor utilization of urea might occur.

FATTENING STUDIES

EXPERIMENTAL PROCEDURE

Trial I

This experiment included two separate trials which were conducted under similar conditions with identical objectives. In the initial study, 32 Hereford and Angus steers averaging 696 pounds were taken off pasture and placed into four lots of eight steers each on the basis of weight, grade, and breed. These steers were used in an 84-day feeding study (May 8 through July 31, 1954) after a period of 21 days to get them "on feed."

The basal ration consisted of grass hay, ground yellow corn, cane molasses, cottonseed meal, and minerals. Protein supplements were as follows: Lot 1, cottonseed meal; Lot 2, 50 percent cottonseed meal and 50 percent urea (nitrogen basis); Lot 3, urea; Lot 4, urea plus 10 milligrams of stilbestrol per steer per day. Additional corn was fed the lots receiving urea to give equivalent total digestible nutrients and crude protein.

Minerals were fed in a partitioned box with loose salt in one side and dicalcium phosphate in the other. For lots receiving urea, it was stirred into the molasses, then poured over the grain. Number 2 coarsely ground yellow corn was used as the major concentrate. The stilbestrol was dissolved in vegetable oil and mixed with ground corn so that 1 pound of the mixture contained the daily desired amount of stilbestrol for the lot receiving stilbestrol. This mixture was sprinkled over the concentrate feed. Samples of corn, molasses, hay, and cottonseed meal were taken and analyzed for each 28-day period.

Chemical analyses (Table 1) were made on all feed ingredients according to the procedures listed by the Association of Official Agricultural Chemists (1950), or with slight modifications. The steers were weighed each 28 days. Live weight grades were determined by the average of two individuals' grading, and the initial value was set at what the steers would have brought on the market. Dressing percentage was figured from selling weight at the packing house and hot carcass weight. Carcass grades were U.S.D.A. grades. A method described by Snedecor (1946) was used for statistical analysis.

Trial II

In the second study, 30 Hereford steers averaging 757 pounds were separated into two lots of 8 steers each (Lots 1 and 2) and two

TABLE 1.—Average Percentage Composition of Feeds for Fattening Studies.

	Hay	Corn	CSM*	Urea	Molasses
			Percent		
			Trial I		
Moisture	9.7	15.2	9.4	——	15.3
Crude protein	6.6	9.0	40.0	261.1	2.9
Ash	6.0	1.5	5.8	——	9.0
Ether extract	1.8	3.0	5.8	——	——
Crude fiber	36.4	1.7	9.5	——	——
N.F.E.**	39.5	69.6	29.5	——	72.8
			Trial II		
Moisture	13.5	12.9	8.2	——	23.7
Crude protein	10.3	9.4	39.3	262.0	2.7
Ash	6.1	1.5	5.2	——	7.0
Ether extract	2.0	4.3	5.1	——	——
Crude fiber	31.0	2.5	11.0	——	——
N.F.E.	37.1	69.4	31.2	——	66.6

*CSM—Cottonseed meal. **Nitrogen-free extract.

lots of 7 steers (Lots 3 and 4). A 108-day feeding study (September 9 through December 26, 1955) was conducted.

All steers were fed twice daily with the exception of omitting the concentrate at each Sunday evening feeding during the period. The hay used in the second trial was a grass-legume mixture containing about one-third legume, but otherwise the ration constituents were quite similar to those in the initial study. Three composited samples of ration ingredients were analyzed during the period, and the average results are shown in Table 1. The percentage shrink was figured from the difference between final weight at the feed-lot and the selling weight at the packing house, which involved a hauling distance of about 10 miles. With the exception of the modifications listed above, the experimental procedure used was very similar to that used in the first study.

RESULTS AND DISCUSSION

Trial I

In the initial study, the average daily rates of gain were 2.05, 2.12, 1.76, and 2.11 pounds for steers in Lots 1, 2, 3, and 4, respectively (Table 2). The steers in Lot 3 gained approximately 0.4 pound less per day than the steers in the other lots. However, this difference was not statistically significant at the 5 percent level nor were any of the differences in feed requirement or cost. The steers in Lot 2 that received cottonseed meal and urea made the most efficient gains with a total of 1,088 pounds of feed required per hundred pounds of gain. Lots 1 and 4 steers required 1,130 and

TABLE 2.—Performance of Steers Fed Urea and Stilbestrol in Fattening Rations (Trial I).

Items	Lot numbers 1	2	3	4
Supplement	CSM*	CSM + Urea	Urea	Urea + stilbestrol
Number of animals	8	8	8	8
Av. wt. per animal (lb.)				
Initial weight	696	696	696	696
Final weight	868	874	844	873
Total gain	172	178	148	177
Daily gain	2.05	2.12	1.76	2.11
Av. daily ration (lb.)				
Hay	9.6	9.6	9.6	9.8
Corn	6.1	7.1	8.0	9.4
CSM	2.4	1.2	—	—
Urea	—	0.15	0.30	0.30
Molasses	5.0	5.0	5.0	5.0
Protein percentage				
As fed basis	9.9	9.9	10.0	9.9
Dry matter basis	11.4	11.5	11.5	11.5
From urea	—	2.0	3.8	3.7
Feed per cwt. gain (lb.)				
Hay	470	453	544	466
Corn	297	335	457	445
CSM	119	57	—	—
Urea	—	7	17	14
Molasses	244	236	284	237
Total	1130	1088	1302	1162
Feed cost per cwt. gain (dollars)	23.39	22.19	26.00	23.80
Financial results (dollars)				
Initial cost per cwt.	18.00	18.00	18.00	18.00
Av. selling price per cwt.	21.60	21.60	21.60	21.60
Return per animal	21.97	24.01	18.57	21.23
Average animal slaughter grades**				
Initial	8.0	8.0	8.0	8.0
Final				
Live	11.7	11.3	11.3	11.7
Carcass	10.3	10.3	10.3	10.3
Dressing percentage	56.8	55.8	56.3	55.6

*CSM—Cottonseed meal.

**Numerical slaughter and carcass grades were assigned as follows:

15=low prime	14=high choice	11=high good	8=high standard
	13=average choice	10=average good	7=average standard
	12=low choice	9=low good	6=low standard

1,162 pounds of feed (hay and concentrates) per hundred pounds of gain, respectively, and the Lot 3 steers made the least efficient gains by a considerable margin, requiring 1,302 pounds of feed per hundred pounds of gain. Lots 3 and 4 steers (urea versus urea and stilbestrol) showed a difference of 140 pounds of feed per hundred pounds of gain, favoring the stilbestrol group. This represents a saving of approximately 11 percent of total feed.

Feed costs per hundred pounds of gain amounted to $23.39, $22.19, $26.00, and $23.80 for Lots 1, 2, 3, and 4, respectively, using the feed costs listed in Table 10. The feed costs and financial results did not consider cost of labor or returns from manure. As shown in Table 2, the returns are in favor of Lots 2, 1, and 4, respectively. These differences are slight and reflect feed efficiency of the animals in the various lots. The addition of stilbestrol, in the case of Lot 4, increased the return per steer over Lot 3 by $2.66; however, there was additional labor required for mixing the stilbestrol with the feed.

Final live weight grades were slightly higher for the all-cottonseed meal lot and the all-urea-plus-stilbestrol lot. Both showed a grade advantage of 0.4 over the cottonseed meal-urea and urea lots. However, this advantage was not borne out by carcass grades. The percentage shrink was not figured in the initial trial, since the steers were weighed the last 2 days before they were hauled to market.

Trial II

In the second trial rations were formulated theoretically to contain about 11 percent crude protein on a dry matter basis. However, the average percentage protein was approximately 2 percent higher as shown in Table 3. Average daily rates of gain of steers were somewhat higher for Lots 3 and 4 than in Trial 1, being 2.08, 2.17, 2.08, and 2.53 pounds for the four lots respectively. The average daily feed consumed by steers in the second trial was slightly higher than in the case of the initial trial. The higher rates of daily gain are therefore attributed principally to the fact that the steers in Trial II ate more feed of a higher protein content and that the ratio of concentrate to roughage was higher in the second trial.

Gains were quite similar in both trials. The only apparent inconsistency is the difference in gains in the Lots 3 and 4 animals of the separate trials. In Trial I there was considerable difference in daily gains between Lots 2 and 3; but gains were quite similar in Trial II. There seems to be no logical explanation for this deviation between Lots 2 and 3 in the individual trials, except that steers in Trial II received about 2 percent more protein. Further work seems necessary to clarify this point, since the conditions of the

TABLE 3.—Performance of Steers Fed Urea and Stilbestrol in Fattening Rations (Trial II).

Items	Lot numbers 1	2	3	4
Supplement	CSM*	CSM + Urea	Urea	Urea + stilbestrol
Number of animals	8	8	7	7
Av. wt. per animal (lb.)				
Initial weight	757	756	758	757
Final weight	981	990	982	1030
Total gain	224	234	224	273
Daily gain	2.08	2.17	2.08	2.53**
Av. daily ration (lb.)				
Hay	6.6	6.5	6.9	7.2
Corn	12.8	13.8	14.2	14.3
CSM	1.8	0.9	—	—
Urea	—	0.14	0.28	0.28
Molasses	3.7	3.7	3.7	3.7
Protein percentage				
As fed basis	10.93	11.22	11.39	11.44
Dry matter basis	12.67	13.12	13.35	13.40
From urea	—	1.73	3.31	3.35
Feed per cwt. gain (lb.)				
Hay	319	300	332	283
Corn, etc.	615	634	685	566
CSM	89	43	—	—
Urea	—	6	13	11
Molasses	177	170	176	147
Total	1200	1153	1206	1007
Feed cost per cwt. gain (dollars)	$28.56	27.28	27.99	23.29
Financial results (dollars)				
Initial cost per cwt.	$18.00	18.00	18.00	18.00
Av. selling price per cwt.	$20.00	20.00	20.00	20.00
Return per animal	-6.84	-7.14	-6.94	0.97
Average animal grades				
Initial	7.2	7.2	7.9	7.1
Final				
Live	10.9	10.9	10.6	11.5
Carcass	10.7	11.1	11.3	10.4
Dressing percentage	59.7	60.7	58.9	58.6
Percent shrink	1.4	2.7***	2.1	2.5***

*CSM—Cottonseed meal. **L.S.D. (P=0.1) = 0.35 pounds per head daily. ***L.S.D. (P=.01) = 0.98 percent shrink.)

first trial indicate that urea does not adequately substitute for all the cottonseed meal needed to balance a low protein fattening ration, while the reverse was found true in the second study. Both trials agreed with the review of literature in that urea does adequately substitute for cottonseed meal, on a nitrogen basis, for one-half of the natural protein supplement necessary to balance low protein fattening rations.

Results of Culbertson **et al.** (1951) agree with the results of the second trial showing that urea can be substituted for all the natural protein supplement used to balance a low protein fattening ration; however, the general concensus in the review of literature agrees with the indication of the initial study that urea does not adequately substitute for all the natural protein supplement.

In the second trial, stilbestrol significantly increased ($P=.01$) the rate of gain of animals in Lot 4 over Lots 1, 2, and 3. Feed efficiency, shown in Table 3 was consistent with daily rate of gain for the various lots of steers and amounted to a total of 1,210, 1,153, 1,206, and 1,007 pounds of feed required per hundred pounds of gain for Lots 1, 2, 3, and 4, respectively. Feed efficiency was consistent in the two trials when steers in Lots 1 and 2 and Lots 3 and 4 are compared. In the case of steers in Lots 3 and 4, stilbestrol reduced the feed required per hundred pounds of gain by about 17 percent, which amounted to a difference of $4.70 in feed cost per hundred pounds of gain.

The financial results (Table 3) show returns per animal for the second trial to be considerably lower than those obtained in the initial trial. This difference is principally due to the fact that the steers in the initial trial brought $1.60 more per hundred weight than in the second trial, while the initial values per hundred weight were the same. It is interesting to note that the use of stilbestrol increased the return per steer by $7.88 over the average for the Lot 3 steers; however, this does not include the cost of additional labor required for mixing the stilbestrol with the feed.

As in the initial trial, grade and dressing percentages were unaffected by treatment. The percentage shrink was found to be significantly lower in the case of Lot 1 over Lots 2 and 4, and to approach significance at the 5 percent level over Lot 3. This shows that a combination of urea and cottonseed meal supplement and urea plus stilbestrol resulted in an increased percentage shrink under the conditions of this study. Schrum and Riggs (1948) found an increase in shrink due to urea supplementation and Perry **et al.** (1955) noted increased shrink due to oral administration of estrogenic substances in beef steers.

No undesirable side effects were noted in either trial from the stilbestrol added to the rations of the Lot 4 animals. However, increased teat length was noted in both trials. Teat length of animals in Lot 4 varied from one and one-half to four times that of the animals in Lot 3.

WINTERING STUDIES

In wintering beef cattle, it is necessary to add protein supplements to the majority of roughages. Young cattle need to be carried through the winter on an economical basis, but they still should be in a thrifty, growing condition. Much interest has been shown in comparisons of different protein supplements for wintering farm livestock. Cottonseed meal and soybean meal have been used in livestock rations for a long time. However, much interest has been shown in feeding supplements such as Purdue A and supplements containing urea.

One phase of the urea experiments was designed (1) to compare urea with cottonseed meal and Purdue supplement A as protein supplements for wintering beef calves and beef cows; and (2) to compare the value of these supplements when fed with hay and when fed with corn silage and hay.

TABLE 4.—Composition of Pelleted Protein Supplements Used for Wintering Beef Cattle.

Items	Supplement numbers 1	2	3	4	5	6
			Percent			
Protein content	41	32	32	32	32	41
Constituent (Material)						
Corn		28	76	70		48
CSM*	100	72	17	18		45
Urea			7**	7**		7***
Molasses				5		
Purdue A					100	

*Cottonseed meal.
**57% of nitrogen from urea.
***45% of nitrogen from urea.

TABLE 5.—Average Percentage Composition of Wintering Roughages

Location and roughage	Moisture	Crude protein	Ether extract	Crude fiber	NFE*	Ash
Oak Ridge I			Percent			
Orchardgrass hay	9.4	8.1	1.7	34.1	40.6	6.1
Corn silage	63.9	3.1	0.9	7.8	22.7	1.6
Oak Ridge II						
Orchardgrass hay	7.0	8.7	2.3	35.6	40.3	6.1
Corn silage	64.4	2.8	0.9	10.4	20.0	1.5
Crossville						
Mixed grass hay	11.1	6.8	1.4	32.8	44.1	3.8
Oat hay	10.9	5.7	2.0	32.4	45.0	4.0
Corn & sorghum silage	73.6	2.1	0.6	7.5	15.2	1.0

*Nitrogen-free extract.

1. WINTERING STUDIES AT OAK RIDGE

EXPERIMENTAL PROCEDURE

Cattle

Two separate trials were conducted with heifer calves during the winters of 1954-55 and 1955-56. Heifer calves in both trials had been weaned for at least 30 days before being placed on these experiments. In the first trial 100 grade Hereford heifer calves averaging 478 pounds each were divided into 10 lots of 10 each on the basis of breeding, weight, type, and condition and then were wintered for 113 days. In the second trial, 120 grade Hereford calves averaging 424 pounds each were divided on the same basis into 12 lots of 10 heifers each and then were wintered for 129 days.

Feeding

The heifers were fed once daily and were weighed every 28 days. In each trial, six lots were fed all the corn silage they would consume plus a limited amount of orchardgrass hay, and four lots received all the orchardgrass hay they would consume. Each lot of calves received a pelleted protein supplement at the rate of 1 pound per head per day. As shown in Table 4, six protein supplements were composed of cottonseed meal, Purdue supplement A, and three supplements contained 7 percent urea. Each of these supplements was mixed and pelleted by a commercial feed mill. The composition of the roughages used in these wintering studies is given in Table 5. The corn silage used was estimated to yield 50 bushels of corn and the orchardgrass hay was of fair quality. Chemical analyses were made according to procedures listed by the Association of Official Agricultural Chemists (1950) or with slight modifications of those procedures. Statistical analyses of data were determined by procedures listed by Snedecor (1946).

The second trial differed from the first in that two additional lots of calves were on winter pasture consisting of oats, ryegrass, and button clover. The calves on pasture had access to grass hay but were not fed a protein supplement. Salt and a mineral mixture of salt, dicalcium phosphate and ground limestone were available free choice to all cattle.

RESULTS

Trial I

The results of this trial are reported in Table 6. The average daily gains varied between 1.58 and 0.93 pounds. Lot 1 heifers on cottonseed meal, corn silage and hay made the fastest gains of any lot fed corn silage, but gains were not significantly greater than for heifers in any other silage lot. On the average the corn silage lots gained 0.5 pounds more per head per day than the hay lots, which was statistically significant. None of the heifers showed any refusal of the supplements. This agrees with results by Gallup **et al.** (1953), but is in contrast with the results reported by Bowstead and Fredeen (1948) who stated that urea and urea-containing supplements were unpalatable.

Trial II

The average daily gains varied between 1.25 and 0.34 pounds per day in this trial for Lots 1 through 10 (Table 7). Lot 1 heifers on cottonseed meal, corn silage and hay made the fastest gain of any of the corn silage lots. One calf in this lot became sick during the second weigh period and was removed from the test. The calves fed silage gained an average of 1.06 pounds per day compared with 0.44 pound for the calves fed hay.

In addition to the lots listed in Table 7, the two lots of calves on pasture made an average daily gain of 1.52 and 1.53 pounds. All calves showed loss of condition during the experiment, but those on pasture showed the least loss. In both trials calves showed no refusals of supplements. This indicates that these supplements were palatable.

OBSERVATIONS ON WINTERING BEEF HEIFERS AT OAK RIDGE

Average values for the 2 years are presented graphically in Figure 1. There were large differences between the gains for the 2 years, but the differences between the treatments were similar. There were small but not significant differences in gains on the different protein supplements with the same basic feeds. There were large differences between the average daily gain of the beef heifers due to feeding of hay in comparison with feeding silage and hay or winter pasture.

With the **ad libitum** consumption of silage, the heifers averaged 3 pounds of silage for each pound of hay replaced. However, when the hay replacement was calculated for silage on the basis of feed per hundred pounds of gain, it took only 1.12 pounds of silage to replace 1 pound of hay. This value was obtained by first subtracting the average pounds of hay fed per hundred pounds of gain for the silage lots from the average pounds of hay fed the

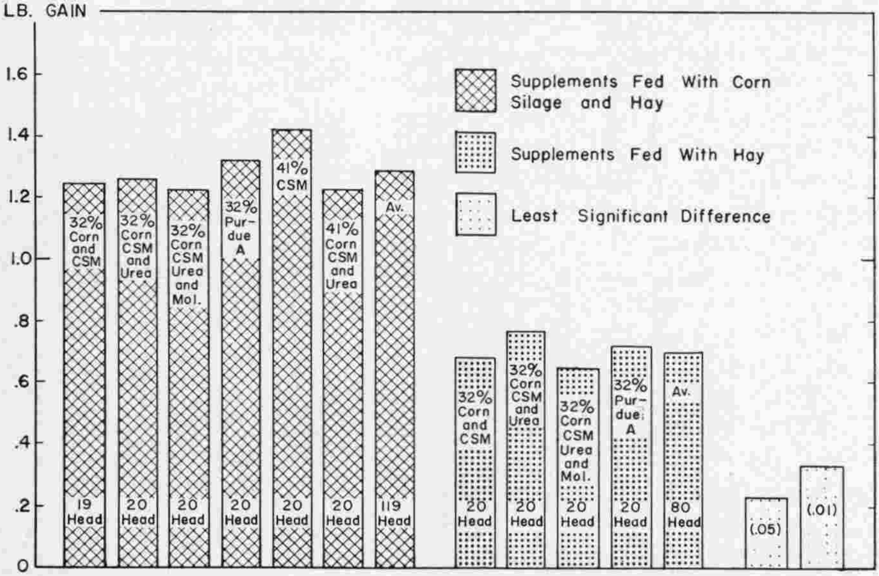

FIGURE 1.—Supplement and roughage comparisons for wintering beef heifers at Oak Ridge (2 year average).

hay lots, then by calculating for the number of pounds of silage required to replace each pound of hay.

Silage values

The silage replacement for hay (3:1) in actual amount consumed agrees with the estimated feed prices shown in Table 10 using $24 per ton for hay and $8 per ton for silage. Using the average percentage composition of the feeds listed in Table 5 and obtaining TDN or total digestible nutrients for similar feeds listed in Morrison (1956), it was found that the average daily TDN consumption for the heifers fed silage was 7.4 and 6.4 pounds for the heifers fed hay. When the calculated TDN consumed per hundred pounds of gain is compared between silage and hay, it was found that 597 pounds of TDN was required for the silage lots compared with 1,024 pounds for the hay lots.

It is difficult to assess a true hay replacement value for silage, but from these data it can be seen that silage is worth considerably more than one-third the value of hay. The heifers fed the silage were about two-thirds of a grade higher in condition than those fed hay, and in the second trial the ones on winter pasture were about two-thirds of a grade higher than the ones fed silage. The feed cost per hundred pounds of gain was considerably less for the silage than for the hay lots. On the average, urea effectively replaced part of the cottonseed meal in these supplements.

TABLE 6.—Winter Performance of Beef Heifers Fed Urea in Protein Supplements (First Trial) December 27, 1954 to April 19, 1955 113 Days

	Corn silage and hay						Orchardgrass hay			
Lot numbers	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Protein content	**41%**	**32%**				**41%**	**32%**			
Supplement	**CSM**	***CSM, & corn**	**CSM, corn & urea**	**CSM, corn, urea & mol.**	**Pur-due A**	**CSM, corn & urea**	**CSM & corn**	**CSM, corn & urea**	**CSM, corn, urea & mol.**	**Purdue A**
No. of animals	10	10	10	10	10	10	10	10	10	10
Av. wt./animal										
Initial wt.	490	487	485	486	487	491	485	483	475	482
Final wt.	669	649	651	658	663	656	590	595	584	596
Daily gain	1.58	1.43	1.47	1.52	1.56	1.46	0.93	0.99	0.97	1.01
Av. daily ration										
Hay	3.23	3.16	3.12	3.26	3.12	3.37	13.14	13.24	12.84	12.96
Corn silage	22.97	22.91	22.80	22.88	22.96	22.78	—	—	—	
Supplement	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salt	.04	.04	.03	.05	.04	.03	.04	.04	.03	.05
Mineral	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
Feed/cwt. gain										
Hay	204	221	212	214	200	230	1411	1341	1325	1279
Silage	1449	1598	1553	1505	1472	1557	—	—	—	—
Supplement	63	70	68	66	64	68	107	101	103	99
Salt	3	3	2	3	3	2	4	4	3	5
Mineral	1	1	1	1	1	1	1	1	1	1
Total	1720	1893	1836	1789	1740	1858	1523	1447	1432	1384
Feed cost/cwt. gain	$13.07	14.53	14.03	13.66	13.35	14.46	26.14	24.70	24.43	23.79
Animal grades										
Initial type	10.7	10.3	10.7	10.8	10.6	10.6	11.2	10.4	10.4	10.7
Initial cond.	10.4	10.3	10.1	10.0	10.2	10.3	10.2	10.1	9.9	10.4
Final type	9.8	9.8	9.6	10.2	10.0	10.1	9.8	9.4	10.0	9.6
Final cond.	7.7	8.3	8.0	8.3	8.5	8.2	6.5	6.1	6.5	6.3

L.S.D. (P=0.05) = 0.23 lb. of gain per day. *CSM—Cottonseed meal.

TABLE 7.—Winter Performance of Beef Heifers Fed Urea in Protein Supplements (Second Trial) December 2, 1955 to April 9, 1956—129 Days

	Corn silage and hay						Orchardgrass hay			
Lot numbers	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Protein content	**41%**	**32%**				**41%**	**32%**			
Supplement	**CSM**	***CSM, & corn**	**CSM, corn & urea**	**CSM, corn, urea & mol.**	**Purdue A**	**CSM, corn & urea**	**CSM & corn**	**CSM, corn & urea**	**CSM, corn, urea & mol.**	**Purdue A**
No. of animals	9	10	10	10	10	10	10	10	10	10
Av. wt./animal										
Initial wt.	433	421	420	428	425	423	424	422	423	424
Final wt.	594	557	556	546	566	552	481	492	467	480
Daily gain	1.25	1.06	1.06	0.92	1.10	1.00	0.44	0.54	0.34	0.43
Av. da. ration										
Hay	2.75	2.66	2.66	2.73	2.73	2.86	9.80	9.76	9.73	9.65
Corn silage	22.45	20.75	20.76	20.69	20.60	20.77	—	—	—	—
Supplement	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salt	.04	.04	.05	.05	.04	.04	.03	.03	.03	.03
Mineral	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
Feed/cwt. gain										
Hay	220	252	252	297	249	285	2212	1811	2833	2242
Silage	1792	1961	1962	2252	1878	2069	—	—	—	—
Supplement	79	94	94	109	91	100	226	186	291	232
Salt	4	4	4	5	4	4	7	6	9	8
Mineral	1	1	1	1	1	1	2	1	2	2
Total	2096	2312	2313	2664	2223	2459	2447	2004	3135	2484
Feed cost/cwt. gain	$12.84	14.39	14.10	16.25	14.11	15.19	35.65	28.63	44.58	36.74
Animal grades										
Initial type	11	11	11	10	11	11	11	11	11	11
Initial cond.	10	10	10	10	10	9	10	10	10	10
Final type	9	9	9.3	9	9.2	9	8.5	9	8	8.5
Final cond.	6.3	5.5	5.8	4.7	5.7	5.5	3	4	3	2.7

L.S.D. (P=0.05) = 0.23 lb. of gain per day.

*CSM—Cottonseed meal.

2. WINTERING STUDIES AT PLATEAU EXPERIMENT STATION

EXPERIMENTAL PROCEDURE

Calves

During the first year 26 steer calves averaging 409 pounds were divided into two lots of 13 each on the basis of weight, condition and type. They then were wintered for 99 days. All steers were fed all of the corn and sorghum silage they would consume plus 2 pounds of mixed hay. In addition the steers in Lot 1 were fed 1 pound of cottonseed meal; Lot 2 steers were fed 1 pound of the 41 percent cottonseed meal, corn, and urea supplement. These are the same supplements which were fed to the calves in the Oak Ridge experiments.

In the second year of these studies, 56 steers and heifers averaging 452 pounds were divided into eight lots of 7 each on the basis of sex, age, weight, condition, type, and sires. The first six lots were fed all the corn-sorghum silage they would consume, plus a limited amount of mixed hay. The other two lots were fed either all the mixed grass hay or oat hay they would consume. In addition each lot was fed minerals free choice plus 1 pound of protein supplement per head for a period of 126 days. The six different protein supplements, as shown in Table 4, were fed to the lots receiving silage. Cottonseed meal was fed to the lots on mixed hay and oat hay. Table 5 shows the average chemical composition of each of the roughages used in these experiments.

Cows

In addition to the calves, during the first winter 52 pregnant Angus cows averaging 948 pounds were divided into three lots on the basis of weight, condition, and type, and they were placed on the treatment rations as shown in Table 10. For 71 days they were fed all the oat straw they would consume plus a limited amount of mixed hay and corn silage. In addition to free access to minerals, one lot was fed 41 percent cottonseed meal and urea pellets at the rate of 1 pound of supplement per head daily.

During the second winter, 48 pregnant Angus cows averaging 978 pounds were divided into three lots of 16 cows each on the basis of weight, condition, and type. They were fed all of the oat straw they would consume plus a limited amount of hay for 88 days. In addition to minerals fed free choice, they were fed the same protein supplements as the cows were fed during the previous year. During the early part of this trial, the cows did get some additional feed by grazing permanent pasture. The test ended when the cows started calving, as additional feed was needed.

RESULTS AND DISCUSSION

Calves

The results of the calf wintering studies are shown in Tables 8 and 9. During the first year the gains were almost the same for cattle fed either cottonseed meal or the supplement containing urea. However, during the second year the results showed that there were differences in the rate of gain among calves fed the same roughages but different supplements.

Of the calves fed corn and sorghum silage, those fed Purdue supplement A made the fastest (1.3 pounds per day) and most economical gains, while the lot fed a 32 percent protein supplement containing urea made the lowest (1.01 pounds per day) and most expensive gains.

The three lots of calves fed urea made an average daily gain of 1.04 pounds compared with 1.1 pounds for the cottonseed meal lots fed the same percentage protein. The analyses of the mixed hay and oat hay fed during the first 28 days were 5.8 and 5.1 percent protein. This indicated that calves in Lots 7 and 8 were not getting enough protein. Therefore the supplement was increased to 1.5 pounds per head for the rest of the wintering period.

The mixed hay and the oat hay were both mature, and when they were supplemented with a daily average of 1.4 pounds of cottonseed meal the combination did not produce gains comparable with Lot 1, which was fed 1 pound of cottonseed meal added to corn and sorghum silage plus hay. Under these conditions, oat hay was better than mixed hay. The condition grade of the calves was lower because the initial grade was taken at weaning time when the calves were carrying considerable condition, while the final condition grade was taken after wintering.

Cows

The results of the cow wintering studies are shown in Table 10. These Angus cows were showing considerable condition at the start of the wintering project. They maintained this weight fairly well throughout the experiment and the loss in weight for cows in Lots 1 and 3 during the second year can partly be explained by the fact that two cows calved in Lot 1 and one cow calved in Lot 3 just 3 days before the final weigh day. These results indicate that there were only slight differences in value among the protein supplements, cottonseed meal, Purdue A, and one containing urea for wintering pregnant beef cows on straw and a limited feed of hay.

OBSERVATIONS ON WINTERING STUDIES AT PLATEAU EXPERIMENT STATION

Corn and sorghum silage plus hay was superior to either mixed hay or oat hay as roughages for wintering beef calves (1.17 pounds gain per day compared with 0.73 and 0.96 pounds, respectively). Purdue supplement A was slightly better than any of the other supplements tested when added to the silage rations. Satisfactory results were obtained in wintering pregnant beef cows fed oat straw and hay plus either Purdue A, cottonseed meal, or a supplement containing urea.

TABLE 8.—Winter Performance of Beef Calves Fed Different Supplements (Plateau Experiment Station, December 2, 1954-March 11, 1955—99 Days)

	Trial 1	Trial 2
Supplement	**41% CSM***	**41% CSM, corn and urea**
No. of animals per lot	13	13
Av. wt. per animal		
Initial weight	410	408
Final weight	511	512
Daily gain	1.01	1.04
Av. daily ration per animal		
Mixed hay	1.97	1.97
Corn and sorghum silage	16.45	16.43
Supplement	.99	.99
Total	19.41	19.39
Feed cost/cwt. gain	$12.51	$12.24
Feed/cwt. gain		
Mixed hay	192	188
Corn and sorghum silage	1601	1566
Supplement	96	94
Total	1889	1848

*CSM—Cottonseed meal.

TABLE 9.—Winter Performance of Weanling Beef Calves Fed Different Roughages and Supplements (November 22, 1955 to March 28, 1956—126 Days)

	Corn and Sorghum silage plus hay						Mixed hay	Oat hay
Lot numbers	1	2	3	4	5	6	7	8
Protein content	41%	32%				41%	41%	
Supplement	**CSM***	**CSM & corn**	**CSM, urea & corn**	**CSM, urea, corn, & mol.**	**Purdue A**	**CSM, corn & urea**	**CSM**	**CSM**
No. of animals per lot	7	7	7	7	7	7	7	7
Av. wt./animal								
Initial wt.	456	456	453	454	450	465	453	446
Final wt.	604	586	580	584	614	600	545	567
Daily gain**	1.17	1.03	1.01	1.03	1.30	1.07	0.73	0.96
Av. daily ration/animal								
Hay	1.99	1.99	1.98	1.98	1.99	2.00	8.68	10.35
Silage	20.00	19.80	19.66	19.92	20.29	20.32	—	—
Supplement	1.00	1.00	1.00	0.99	1.00	1.00	1.39	1.38
Salt	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03
Mineral	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.05
Feed/cwt. gain, lb.								
Hay	170	193	197	192	154	187	1184	1080
Silage	1703	1923	1960	1929	1566	1901	—	—
Supplement	85	97	100	96	77	93	190	144
Salt	3	3	3	3	2	3	3	3
Mineral	4	6	6	6	5	6	8	5
Total	1965	2222	2266	2226	1804	2190	1386	1232
Feed cost/cwt. gain	$12.02	13.57	13.88	13.50	11.11	13.29	21.22	18.28
Animal grades								
Initial type	12	12	12	12	12	12	12	12
Final type	11	10	11	10	11	11	11	10
Initial cond.	11	10	11	11	11	11	11	11
Final cond.	5	4	5	5	6	5	5	4

*CSM—Cottonseed meal.

**L.S.D. at $P<0.05$ = .28 lb./day.

TABLE 10.—Winter Performance of Beef Cows Fed Different Protein Supplements

	Lot number and supplement		
	1	2	3
	41% CSM*	Purdue A	41% CSM, corn & urea
A. December 3, 1954 to February 12, 1955 (71 days)			
No. of animals per lot	17	18	17
Av. wt. per animal			
Initial weight	933	941	969
Final weight	915	915	915
Total gain (lb.)	-18	-26	-54
Av. daily ration per animal			
Mixed hay	8.0	8.0	8.0
Oat straw	9.8	9.7	9.7
Supplement	1.0	1.0	1.0
Corn silage	2.8	2.8	2.8
Total	21.6	21.5	21.5
Total feed cost per cow	$15.99	$16.15	$16.02
B. November 11, 1955 to February 12, 1956 (88 days)			
No. of animals per lot	16	16	16
Av. wt. per cow			
Initial weight	982	984	967
Final weight	967	981	960
Total gain (lb.)	-15	-3	-7
Av. daily ration per cow			
Mixed hay	8.0	8.0	8.0
Oat straw	8.2	7.0	7.2
Supplement	1.0	1.0	1.0
Salt & minerals (ad lib)	.05	.05	.05
Total	17.2	16.0	16.2
Total feed cost per cow	$17.80	$17.06	$17.13
Number of cows calving	16	15	15

*CSM—Cottonseed meal.

TABLE 11.—Estimated Average Feed Prices from May, 1954 to April, 1956

Feed	Cost/ton	Supplements	Cost/ton
Corn	$ 60.00	1 (CSM)	$79.00
CSM	75.00	2	80.80
Molasses	32.00	3	80.10
Urea	110.00	4	78.50
Grass hay	24.00	5 (Purdue A)	83.20
Oat hay	24.00	6	82.60
Oat straw	16.00		
Corn silage	8.00		

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