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Twentieth Annual Cattle Feeders Day

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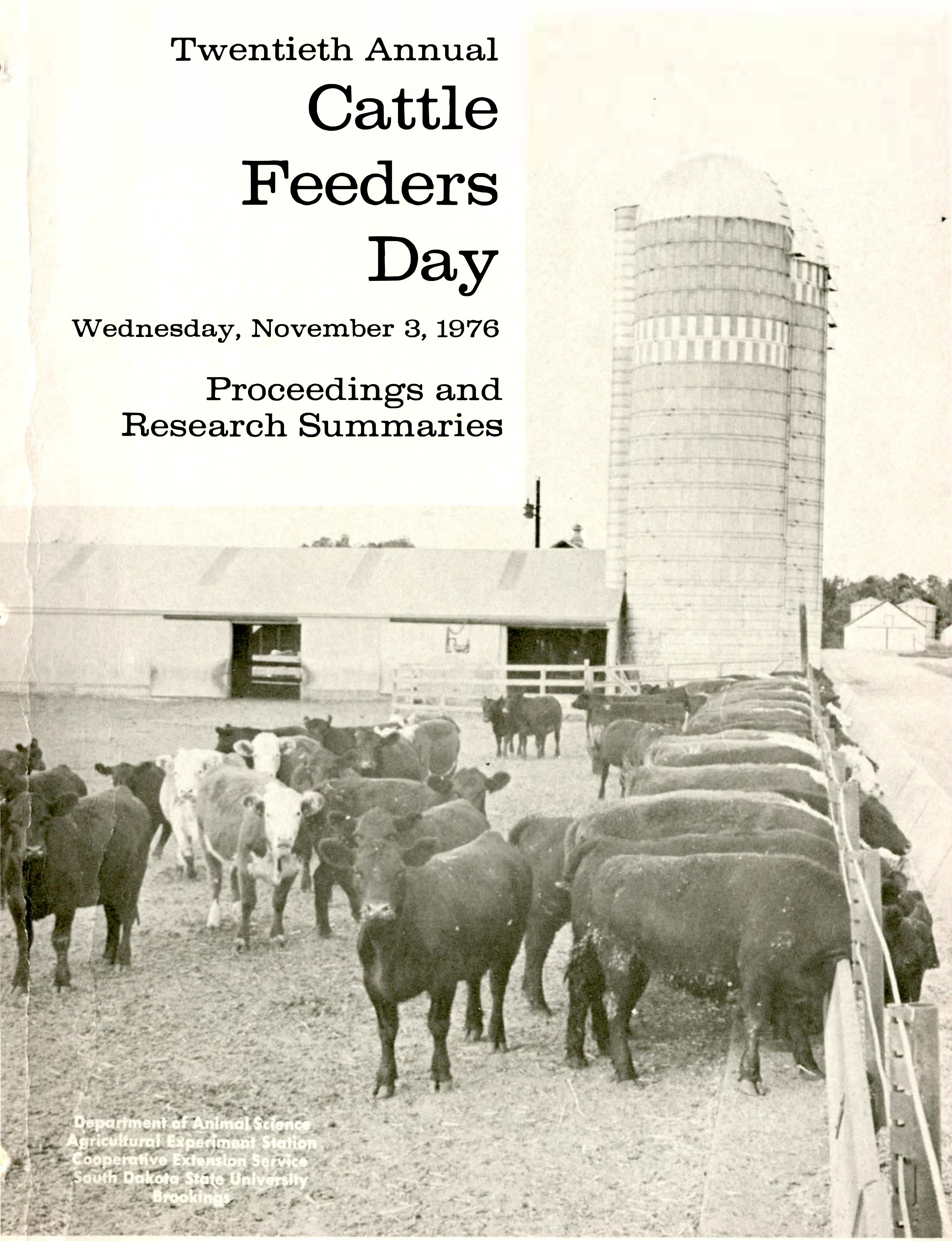
Twentieth Annual

Cattle Feeders Day

Wednesday, November 3, 1976

Proceedings and Research Summaries



Department of Animal Science
Agricultural Experiment Station
Cooperative Extension Service
South Dakota State University
Brookings

Held in conjunction with Conference on Cattle Feeding Opportunities in South Dakota, November 3-4, 1976, Sioux Falls, S. D.

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South Dakota State University
Brookings, South Dakota

Department of Animal Science
Agricultural Experiment Station

A.S. Series 76-12

Delignification of Ponderosa Pine Sawdust and Bark by Peroxyacetic Treatments

L. D. Kamstra, D. Ronning and H. Schroeder

Introduction

Previously it was shown that untreated ponderosa pine sawdust could serve as the roughage portion of high-concentrate rations. This fibrous material was too low in digestibility, however, to serve as a major ration component unless treated to remove encrusting lignin. Various treatments such as pressure, heat and sodium hydroxide, although effective with many fibrous waste material, were only marginal in improving utilization of pine sawdust.

The purpose of this study was to determine effectiveness of peroxyacetic acid in improving the digestibility of highly lignified fibrous materials such as ponderosa pine sawdust and bark. Peroxyacetic acid is used as a delignifying agent in the making of paper from tree fibers.

Materials and Methods

Wood chips from the Whitewood Post and Pole Company, Whitewood, South Dakota, were dried and ground to pass a 4.0 mm screen prior to treatments with peroxyacetic acid. Peroxyacetic acid was prepared by a controlled reaction between hydrogen peroxide and acetic anhydride in sufficient amounts to treat small amounts of wood material. Twenty gram samples of bark and sawdust were treated with various levels of peroxyacetic acid under various conditions. The treated and untreated wood and bark samples were also analyzed for neutral-detergent fiber (NDF), acid-detergent fiber (ADF), acid-detergent lignin (ADL) and evaluated for potential utilization by ruminants by *in vitro* dry matter digestibility (IVDMD) as well as cell wall digestibility (IVCWD). The untreated samples were also analyzed for cellulose, nitrogen and ash.

Results

Untreated ponderosa pine sawdust differed somewhat in analysis from ponderosa pine bark, with the bark having greater lignification and mineral content but less fiber. Note, however, that both ponderosa pine sawdust and bark are highly lignified materials (table 1).

A summary of a series of treatments of ponderosa pine sawdust and bark appears in table 2.

It would appear that peroxyacetic acid is an effective delignifying agent even at low solution concentrations. Almost complete delignification was accomplished with proper conditions of concentration, time and temperature. *In vitro* digestibility increased as lignin was removed from the fibrous material. Little damage to the cell walls or to hemicellulose was noted during removal of lignin by peroxyacetic acid. Usually greater lignification also means less digestibility. However, untreated bark has a higher digestibility than untreated sawdust with a lower lignin content. Lignin structure is known to vary from one plant to another and may also vary at locations within the same plant. As complete delignification is approached, the digestibility of sawdust and bark is similar.

Summary and Conclusions

It appears most practical to remove approximately 60% of the lignin to attain high potential for ruminant utilization of fibrous wastes as measured by *in vitro* digestion. It has a very desirable feature in being almost non-destructive to fibrous material and thus recovery of usable waste feed should be favorable to use. Treating methods such as high pressure, steam, heat or sodium hydroxide additions are more destructive in achieving similar levels of digestive potential. High pressure steam treatment for only 90 seconds, for example, destroys a large portion of hemicellulose as indicated by production of furfural during the reactions. Furfural production results from destruction of five carbon carbohydrates which comprise the major portion of the hemi-cellulose fraction. This would mean a loss of about a third of the digestible dry matter during treatments by such methods rather than by peroxyacetic acid. Peroxyacetic acid treatment demands more safety precautions and sophisticated treatment methodology, however. Its use in production of feeds from highly lignified wastes will depend on the demand for new feeds and the cost of traditional feeds, especially roughages. Animal trials using peroxyacetic acid-treated materials are planned as soon as better methods of synthesis of peroxyacetic acid are developed to treat greater volumes of wastes.

Table 1. Composition of Substrates Treated with Peroxyacetic Acid

	Ponderosa sawdust	Ponderosa bark
	%	%
Neutral-detergent fiber	92.8	74.4
Acid-detergent fiber	79.5	64.5
Acid-detergent lignin	27.4	33.7
Crampton and Maynard cellulose	49.1	26.2
Nitrogen	0.2	0.3
Ash	0.2	3.8

Table 2. Effect of Peroxyacetic Acid Treatment on Ponderosa Pine Sawdust and Bark

Peroxyacetic acid									
Concentration	G/100 g substrate	Time	Temperature	NDF[a]	ADF[b]	ADL[c]	Delignification	IVDMD[d]	IVCWD[e]
%		Hr	°C	%	%	%	%	%	%
				Sawdust					
---	---	---	--	92.8	79.5	27.4	0	7.3	0.2
2.50	20	168	25	88.6	75.9	17.6	35.8	12.6	1.3
3.75	30	168	25	85.7	73.2	14.3	47.8	26.9	14.7
5.00	40	168	25	82.6	71.1	8.7	68.2	48.6	37.7
6.25	50	168	25	79.8	69.5	5.8	78.8	61.5	48.2
7.50	60	168	25	78.5	67.2	3.9	85.8	68.3	59.6
8.75	70	168	25	78.3	65.8	1.5	94.5	72.5	64.9
20.0	200	1	75	73.0	60.8	0.2	99.4	81.1	69.0
20.0	200	2	75	79.0	68.1	0.3	99.1	77.4	71.4
20.0	200	3	75	76.5	67.3	0.1	99.5	80.3	74.2
10.0	100	1	75	77.8	66.2	0.3	99.1	80.5	75.0
10.0	100	2	75	80.4	69.9	0.1	99.5	81.8	77.3
10.0	100	3	75	83.3	73.2	0.2	99.4	81.0	77.2
5.0	50	1	75	77.3	65.7	4.7	82.7	67.9	58.5
5.0	50	2	75	77.0	64.7	1.9	93.2	75.1	67.6
5.0	50	3	75	75.9	64.9	0.9	96.7	78.0	76.7
2.5	25	1	75	90.7	76.3	13.5	50.8	19.1	10.8
2.5	25	2	75	89.6	76.0	11.2	59.0	30.3	22.2
2.5	25	3	75	89.1	76.4	9.6	64.9	38.7	31.2
2.5	25	1	85	88.8	76.2	14.0	49.0	28.4	14.1
2.5	25	2	85	89.7	75.8	13.0	52.6	38.2	27.0
2.5	25	3	85	88.6	76.1	13.2	51.9	37.8	25.6
2.0	20	1	85	87.1	76.4	16.3	40.7	15.5	2.9
2.0	20	2	85	86.1	76.7	15.7	42.8	18.9	5.9
2.0	20	3	85	85.9	77.2	15.6	43.2	19.0	5.8
				Bark					
0	0	---	---	74.4	64.5	33.7	0	30.0	5.9
4.0	20	168	25	67.3	60.8	24.8	26.3	46.6	20.6
6.0	30	168	25	68.1	57.9	20.5	39.3	53.2	31.3
8.0	40	168	25	69.4	56.8	16.4	51.3	56.5	37.3
10.0	50	168	25	69.8	55.6	13.8	59.1	60.0	42.7
12.0	60	168	25	68.3	52.9	8.6	74.6	66.9	51.5
14.0	70	168	25	66.1	51.1	5.7	83.2	73.3	59.6

[a] NDF = neutral-detergent fiber.
[b] ADF = acid-detergent fiber.
[c] ADL = acid-detergent lignin.
[d] IVDMD = *in vitro* dry matter digestibility.
[e] IVCWD = *in vitro* cell wall digestibility.

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Roughage Quality and Protein Supplementation with High-Concentrate Rations for Finishing Cattle

R. N. Gates and L. B. Embry

Feedlot cattle have been shown to make high rates of gain with low feed requirements when fed all-concentrate rations during finishing periods up to 6 months or more. However, some roughage has frequently been reported to improve weight gain and to reduce digestive problems associated with all-concentrate rations. Roughage levels of 8 to 10% have appeared adequate for these purposes and are considered to be about optimum on basis of weight gain and feed efficiency. Questions are often raised as to the importance of roughage quality when included in rations at these low levels.

It has been shown on several occasions in recent years that many finishing rations for feedlot cattle over 750 lb. do not benefit from protein supplementation. Numerous experiments during past years have been devoted to determining protein requirements for growing and finishing cattle. Requirements appear to have been determined rather accurately, and the amount needed in the ration is determined largely by the amount of various feeds consumed, digestibility and quality of proteins in the feeds, size of cattle and rate of production. These factors should be considered in determining the need for supplemental protein with various types of growing and finishing rations.

The objectives of this experiment were to determine the benefits of low levels of roughage in comparison to all-concentrate rations for finishing cattle, the importance of roughage quality when fed at low levels and the need for supplemental protein under the various conditions of roughage level and quality.

Procedures

Steers for the experiment had been used previously in a growing experiment for 138 days. They were fed corn silage with variations in level and source of supplemental protein. Upon completion of the growing experiment, all steers were fed a ration which consisted of 5 lb. of high-moisture corn grain and a full feed of alfalfa haylage for a period of 6 weeks. Changing over to an all-concentrate ration was then accomplished over a period of 2 weeks by gradual reductions in the alfalfa haylage and increases in corn grain. Following 4 days of feeding all-concentrate rations, the steers (108 Hereford-Angus and 36 Angus) were allotted on the basis of weight and breed group to 24 pens of 6 each.

Dietary treatments were an all-concentrate control, control plus 2 lb. daily of wheat straw for a poor quality roughage and control plus 2 lb. of bromegrass-alfalfa hay for a good quality roughage. Each of these rations was fed with or without supplemental protein, resulting in the six dietary treatments. Each treatment was fed to four pens of steers with high-moisture corn fed to appetite.

The wheat straw contained 4.52% protein, dry basis, and the bromegrass with a light mix of alfalfa contained 12.35% protein, dry basis. Each roughage was chopped with a forage chopper set for the finest cut possible.

The corn grain was purchased as dry corn. It was stored in an oxygen-limiting silo with water added as it was blown into the silo, resulting in an average moisture content as fed of 21.5%. The protein content averaged 11.5%, dry basis, which exceeds NRC requirements for feedlot steers weighing over 770 pounds. The silage blower resulted in considerable cracking of the grain, and no further processing was used. Average protein content of the all-concentrate control ration was 11.3%. The average protein content of the rations over the entire experiment was reduced approximately 0.7 percentage unit by addition of wheat straw and increased 0.1 percentage unit or less by the bromegrass-alfalfa hay. Protein supplementation resulted in an increase of about 0.7 percentage unit.

A soybean meal based supplement (17% protein, dry basis) was fed at 2 lb. per head daily to steers that received supplemental protein. Cattle that received no supplemental protein were fed 2 lb. per head daily of a corn based supplement which provided the same levels of added minerals, vitamin A, vitamin E and chlortetracycline as the soybean meal supplement. The soybean meal supplement was formulated so that the ration with wheat straw and soybean meal supplement would be about equal in protein content to the ration with bromegrass-alfalfa hay and corn supplement. Ingredient composition of the supplements is shown in table 1.

Table 1. Ingredient Composition of Supplements

Ingredient	SBOM supplement	Corn supplement
	%	%
Corn	44.46	73.03
SBOM (44%)	28.57	---
Limestone	9.93	9.93
Dicalcium phosphate	6.94	6.94
Potassium chloride	6.60	6.60
Trace mineral salt	3.30	3.30
Trace mineral premix	0.20	0.20
Vitamin A premix (30,000 IU/g)	added at rate of 10,000 IU/lb. of supplement	
Vitamin E premix (500 IU/g)	added at rate of 150 IU/lb. of supplement	
Aureomycin-10	added at rate of 35 mg of CTC/lb. of supplement	

Four implant treatments were superimposed over dietary treatments. Implant treatments were balanced with regard to dietary treatments with one pen each of the four serving as nonimplanted controls or implanted with 36 mg diethylstilbestrol (DES), 36 mg zeranol (RAL) or Synovex-S (20 mg estradiol benzoate and 200 mg progesterone).

Feeding was once daily and water was available continuously from automatic waterers. Animals were confined to outside, concrete-paved pens without access to shade or shelter.

Weights were taken at 4-week intervals in early morning before feeding. In addition, initial and final weights were taken following an overnight stand (about 17 hr.) without feed and water. The experiment was terminated after 140 days, animals marketed and carcass data obtained.

Results

There were no apparent interactions between implant treatments and dietary treatments. Therefore, results for dietary treatments presented in the tables were averaged across implant treatments.

Feed Intake

Average daily feed intake accumulated to date by weigh periods is presented in table 2. In all instances, daily feed intake increased with increasing weights and time on the experiment.

Table 2. Cumulative Feed Intake by Weigh Periods as Affected by Roughage Source and Protein Supplement

Roughage	All-concentrate		Wheat straw		Brome hay	
Supplement	Corn	SBOM	Corn	SBOM	Corn	SBOM
No. of animals	24	23[a]	24	24	24	24
Init. shrunk wt., lb.	681	687	677	678	679	679
Final shrunk wt., lb.	1099	1111	1023	1068	1084	1109
Avg. daily feed, lb.						
28 days	14.53	15.05	16.83	16.23	16.21	17.80
56 days	17.92	18.29	19.74	21.23	19.52	21.33
85 days	20.12	20.57	21.84	23.68	22.16	23.76
113 days	21.14	21.52	22.95	24.30	23.41	24.74
140 days	21.65	21.92	23.19	24.73	24.08	25.22
Avg. protein content during expt., %	11.3	12.1	10.7	11.4	11.4	12.1

[a]One loss occurred not believed to be related to experimental diet. Results presented in all tables are averaged for 23 head for this treatment.

Without supplemental protein, steers fed wheat straw consumed an average of 1.5 to 2.3 lb. more feed daily than steers fed the all-concentrate ration. The greatest difference in feed intake between these two groups occurred during the first month of the experiment. After the first month, steers fed wheat straw consumed more total feed but slightly less concentrates (grain and supplement) than those fed the all-concentrate ration.

With supplemental protein, steers fed wheat straw consumed more total concentrates (0.8 to 1.1 lb. daily) than the all-concentrate group at each weigh period except the first one. The data show that supplemental protein had only a minor effect on feed intake with the all-concentrate ration. However, there was a substantial improvement in feed intake from protein supplementation with wheat straw, amounting to 1.3 to 1.8 lb. daily at various periods after the first month.

There was also an improvement in feed intake from feeding of the bromegrass-alfalfa hay in comparison to the all-concentrate rations. The increase over the all-concentrate ration was greater with supplemental protein. Hay was consumed more readily than the straw. However, there were only slight differences in total feed intake between the hay and straw except for a slight advantage for hay near the end of the experiment.

Weight Gain

Weight gains to date by weigh periods are presented in table 3. The 140-day adjusted average daily gain is on basis of the initial shrunk weight and a final weight based on carcass weight, with live weight adjusted to a carcass yield of 62%.

Table 3. Cumulative Weight Gains by Weigh Periods as Affected by Roughage Source and Protein Supplement

Roughage	All-concentrate		Wheat straw		Brome hay	
Supplement	Corn	SBOM	Corn	SBOM	Corn	SBOM
No. of animals	24	23	24	24	24	24
Init. shrunk wt., lb.	681	687	677	678	679	679
Final shrunk wt., lb.	1099	1111	1023	1068	1084	1109
Avg. daily gain, lb.						
28 days	2.22	2.98	2.83	3.16	2.91	3.59
56 days	2.62	3.19	2.64	3.39	2.95	3.40
85 days	2.92	2.98	2.71	3.22	3.00	3.35
113 days	3.02	3.19	2.74	3.06	2.97	3.22
140 days (filled)	3.02	3.08	2.51	2.90	2.95	3.21
140 days (adjusted)	3.08	3.08	2.56	2.95	2.99	3.22

Weight gain during the first month of the experiment when increasing the animals to a full feed was lowest for the all-concentrate ration without supplemental protein. There was considerable improvement for this treatment group after the first month. These cattle had weight gains nearly equal to the all-concentrate group with supplemental protein by end of the third month. There was no advantage for the supplemental protein with all-concentrate rations on the basis of weight gain at the end of the 140-day experiment.

Wheat straw resulted in a marked increase in weight gain during the first month on experiment in comparison to the all-concentrate ration when fed without supplemental protein. After this time, wheat straw without supplemental protein resulted in reduced weight gains.

Wheat straw with protein supplementation resulted in higher weight gains than the comparable all-concentrate ration during the first 3 months of the experiment. Thereafter, these cattle gained at a lower rate than the all-concentrate group with supplemental protein.

There was also a substantial improvement in weight gain from bromegrass-alfalfa hay in comparison to the all-concentrate ration fed without supplemental protein during the first month of the experiment. These cattle fed hay gained at a rather uniform rate throughout the experiment rather than showing a later increase as did the all-concentrate group. After the second month there appeared to be essentially no advantage for the hay on the basis of weight gain.

Supplemental protein with the hay appeared to provide about as much benefit as with the all-concentrate ration during the first 2 months of the experiment. The initial advantage in total gain from supplemental protein with hay was slightly improved during the experiment in contrast to a loss of the initial advantage after about 3 months with the all-concentrate ration.

In direct comparisons between rations with straw or hay, straw was inferior to hay. The difference between rations with straw or hay was less with supplemental protein. Rations with straw and supplemental protein resulted in slightly higher rates of gain during the first 3 months of the experiment than did rations with the hay and no supplemental protein. These rations were approximately equal in total protein content. Over the 140-day experiment, similar weight gains were obtained with these two rations.

Feed Efficiency

Data on feed efficiency are presented in table 4. Feed required per unit of gain increased with increasing time on experiment and weight of the cattle. As would be expected from data presented on feed intake and weight gain, feed to gain ratios were improved by roughage additions during the early part of the experiment. After the first or second month, total feed requirements were higher for rations with roughages. Requirements were increased more with straw than with hay.

Table 4. Cumulative Feed Efficiency by Weigh Periods as Affected by Roughage Source and Protein Supplement

Roughage	All-concentrate		Wheat straw		Brome hay	
Supplement	Corn	SBOM	Corn	SBOM	Corn	SBOM
No. of animals	24	23	24	24	24	24
Init. shrunk wt., lb.	681	687	677	678	679	679
Final shrunk wt., lb.	1099	1111	1023	1068	1084	1109
Feed/gain ratio						
28 days	6.81	5.25	6.09	5.16	5.57	5.01
56 days	6.93	5.74	7.51	6.27	6.67	6.29
85 days	6.89	6.92	8.07	7.37	7.41	7.08
113 days	7.00	6.75	8.39	7.96	7.91	7.69
140 days (filled)	7.16	7.12	9.25	8.50	8.19	7.83
140 days (adjusted)	7.05	7.13	9.08	8.42	8.09	7.84

Protein supplementation improved feed efficiency with all rations during the first 2 months of the experiment. After this time, there was essentially no improvement in feed efficiency from protein supplementation of the all-concentrate ration. Protein supplementation of rations with straw or hay improved feed efficiency with the effect being more pronounced with straw than with hay.

Feed to gain ratios shown by components of the rations for the entire experiment are shown in table 5. Without protein supplementation, requirements for concentrates were increased by feeding straw or hay. This increase was greater for straw than for hay. Feed requirements as concentrates were also increased by feeding straw or hay when rations contained the soybean meal supplement. The increase was less than for rations without supplemental protein but again greater for rations with wheat straw.

Table 5. Feed to Gain Ratio After 140 Days

Roughage	All-concentrate		Wheat straw		Brome hay	
Supplement	Corn	SBOM	Corn	SBOM	Corn	SBOM
Final shrunk wt., lb.	1099	1111	1023	1068	1084	1109
Adjusted avg. daily gain, lb.	3.08	3.08	2.56	2.95	2.99	3.22
Feed to gain ratio						
Corn grain	6.41	6.49	7.53	7.08	6.76	6.63
Supplement	0.64	0.64	0.77	0.67	0.66	0.61
Wheat straw or brome hay	---	---	0.77	0.67	0.67	0.62
Total	7.05	7.13	9.07	8.42	8.09	7.86

The value of straw in comparison to the hay can be estimated from the feed requirement data (table 5). Without protein supplementation, 100 lb. of wheat straw plus 114 lb. of concentrates (corn and corn supplement) were equal to 87 lb. of the hay. It is evident that wheat straw would not be an economical substitute for hay of the quality used under these conditions. With protein supplementation, 100 lb. of the straw plus 67 lb. of corn and 9 lb. of the supplement were equal to 93 lb. of the hay. While more favorable for straw under this condition than without protein supplementation, wheat straw would not likely be an economical substitute for hay of the quality used under conditions as in this experiment. The value of the wheat straw ration might have been improved by a higher level of protein supplementation. Under such conditions, straw would have to be enough cheaper than hay to justify the cost of the additional protein supplementation.

Carcass Data

Carcass data are shown in table 6. Carcasses were graded under the system in use during the fall of 1975. All treatment groups had carcasses grading within the range of low to average Choice. While there were some small differences in carcass characteristics measured, there appeared to be no consistent effects from roughage treatments or protein supplementation other than those associated with weight gain and carcass weight.

Table 6. Carcass Data

Roughage	All-concentrate		Wheat straw		Brome hay	
Supplement	Corn	SBOM	Corn	SBOM	Corn	SBOM
Hot carcass wt., lb.	689	693	641	676	680	700
Marbling[a]	5.7	6.3	5.9	6.5	6.2	6.0
Carcass grade[b]	19.4	19.8	19.6	20.0	19.7	19.6
Percent kidney fat	2.2	2.4	2.7	2.7	2.4	2.3
Rib eye area, sq. in.	11.45	11.47	11.28	10.92	11.15	11.52
Fat thickness, in.	0.71	0.72	0.62	0.74	0.67	0.74

[a]Moderate = 7, modest = 6, small = 5.
[b]Prime = 23, Choice = 20, Good = 17. Graded to one-third grade.

Summary

One hundred forty-four steers averaging about 680 lb. initially were fed for 140 days to determine the benefits of a low level of roughage in comparison to all-concentrate rations, the importance of the quality of roughage when fed at low levels and the need for protein supplementation under the various conditions of roughage level and quality. All-concentrate rations were compared to those with 2 lb. of wheat straw for the low quality roughage and 2 lb. of bromegrass-alfalfa hay for the good quality roughage. All rations were fed with and without supplemental protein. Average protein contents for the entire

experiment were 11.3, 10.7 and 11.4%, respectively, for all-concentrate, wheat straw and hay rations fed without supplemental protein and 12.1, 11.4 and 12.1% when fed with supplemental protein.

Roughage additions and protein supplementation improved feed intake, weight gain and feed efficiency during the first 1 or 2 months of the experiment. Only with wheat straw did there appear to be an advantage for supplemental protein throughout the experiment. Cattle fed all-concentrate rations with or without supplemental protein had the same weight gain and about the same feed efficiency over the entire experiment. The apparent advantage for the supplemental protein for cattle fed the hay could be attributed largely to the improved performance during the early part of the experiment.

Feeding wheat straw without protein supplementation reduced weight gains and increased feed requirements. While performance was improved with supplemental protein, weight gains were slightly lower than for cattle fed the all-concentrate ration and total concentrate requirements were higher.

Feeding bromegrass-alfalfa hay without supplemental protein resulted in no improvement in weight gains over the all-concentrate ration for the entire experiment with a higher requirement for concentrates. While overall weight gains were higher with protein supplementation, there was no reduction in requirement for total concentrates by feeding hay.

In direct comparisons between straw and hay, straw was inferior to the hay. Cattle performance was improved more by protein supplementation with straw than with hay. There were only small differences between cattle fed straw with supplemental protein and cattle fed the hay without supplemental protein. Under such conditions, straw could be an economical substitute for hay if the price was enough lower than for hay to justify the additional supplemental protein.

Dietary treatments appeared to have no consistent effect on carcass characteristics measured except as influenced by weight gain and carcass weight.

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A.S. Series 76-14

Processing of Oats in Limited Grain Rations for Wintering Calves

L. B. Embry and D. E. Overbay

Hay fed to appetite along with 5 to 6 lb. of grain is a common ration for growing calves for herd replacements or later feedlot finishing. Feeding could be simplified and costs reduced by feeding grain in the whole form. Studies with corn have often shown some improvement in weight gain and feed efficiency from processing the grain for cattle where the roughage level exceeds about 20% of the dry ration. Sorghum grain, wheat and barley appear to benefit more from processing than does corn grain.

Rations for growing calves often contain 50% or more roughage dry matter. This is a level above which it appears some method of processing should be used for the grain. However, there seems to be less effect from processing grain for calves during the first winter following weaning than for older feedlot cattle.

Hay with a limited feed of oats is a common ration for wintering calves. The oats are commonly ground or rolled. The experiments reported here were conducted to compare whole oats with ground or rolled oats when fed at levels of 5 to 6 lb. per head daily with a full feed of alfalfa as hay or haylage in rations for wintering calves.

Experiment 1

Procedures

One hundred twenty steer calves were purchased for the experiment. They were allotted into 8 pens of 15 each on basis of weight. Those in four pens were fed whole oats and those in the other four pens were fed ground oats. Rations consisted of 5 lb. oats, 1 lb. of supplement and a full feed of alfalfa hay.

The pelleted supplement was composed of ground oats with 6% trace mineral salt, 5% cane molasses and vitamin A to furnish 20,000 IU per pound of supplement. The alfalfa hay was field chopped at 20 to 25% moisture, stacked in 12- to 15-ton stacks and dried by use of ducts and a fan with unheated air. Average protein content on a moisture-free basis was approximately 17.5%.

A hammer mill was used to grind the oats for the group which received this treatment. The oats were ground to pass a 3/8 inch screen so no whole kernels remained. The average protein content was about 15%.

The cattle were fed in outside, unpaved pens without access to shelter. Feeding was once daily with hay offered in about equal amounts to all pens of cattle.

Results

The experiment was started in December and terminated after 203 days. Initial and final weights represent an overnight stand without feed and water.

Daily rate of gain was essentially the same for steers fed whole (1.44 lb.) or ground (1.42 lb.) oats at 5 lb. daily with 1 lb. of supplement and a full feed of chopped alfalfa hay. The hay was fed at approximately the same rate for both groups of cattle. It was offered in excess of consumption, but there was no noticeable difference in amount refused between the two treatment groups of cattle. In this case, feed efficiency was similar for whole and ground oats as was the rate of gain.

A total of seven steers died or were removed during the experiment. Three were fed whole oats and four were fed ground oats. Thus, there appeared to be no difference in grain preparation treatments on these losses. Rations of alfalfa hay and oats as fed in this experiment sometimes present problems from bloat. However, none of the losses were from bloat, and this condition did not present a problem during the experiment.

Experiment 2

Procedures

In view of the excess in feeding hay in experiment 1, it was considered desirable to conduct another experiment where the roughage portion of the ration was fed at levels that would be almost completely consumed. Twenty-six steers were used in the experiment. They were allotted into 4 pens of 6 or 7 per pen on basis of weight. Two pens were fed whole oats and two fed rolled oats at 6 lb. per head daily. Alfalfa-brome haylage (44% dry matter) was full-fed in amounts to be nearly consumed by the next feeding. No supplement was fed to the cattle, but they were offered free access to a calcium-phosphorus supplement and trace mineral salt. The oats were rolled to a fineness so most of the kernels would be cracked.

Feeding during this experiment was once daily in outside, concrete-paved pens without access to shelter.

Results

This experiment was started in mid-December and terminated after 149 days. Initial and final weights represent an overnight stand without feed and water. Results are presented in table 2.

Daily rates of gain were similar for cattle fed whole (1.57 lb.) and rolled oats (1.45 lb.). These rates of gain differ only slightly from the first experiment, also started in mid-December but continued for 203 days. The oat grain was fed at the same level for the whole and rolled groups. Those fed whole oats consumed an average of about 2 lb. more haylage daily (44% dry matter). They had a slightly higher rate of gain, resulting in a similar feed efficiency as for those fed the rolled oats.

No losses occurred during this experiment and no digestive problems were encountered from the oats and alfalfa-bromegrass haylage.

Summary and Comments

Results of two wintering experiments started in mid-December (203 and 149 days) with steer calves showed essentially no difference on basis of weight gain and feed efficiency between oats fed whole and rolled or ground at levels of 5 or 6 lb. daily with a full feed of chopped alfalfa hay or alfalfa-bromegrass haylage. Bloat or other digestive disorders did not present problems during the experiments. Some losses occurred in one experiment, but losses were about the same for whole or ground grain treatments and did not appear to be related to rations fed.

Protein contents of alfalfa and oats are generally in excess of percent protein recommended in rations for growing calves. Thus, any supplement fed could be composed largely of grain. The primary purpose of a supplement would be to serve as a carrier for added minerals, vitamin A and desired feed additives.

Rates of gain obtained from alfalfa hay or haylage and 6 lb. of oats or oats and supplement ranged from 1.42 to 1.57 lb. daily in the two experiments. These rates of gain represent satisfactory ones for growing calves for herd replacements or later feedlot finishing. Feed costs for growing calves with these rations can be calculated from feed requirement data presented in the tables by use of appropriate prices for the feedstuffs. Proper charges should be made for nonfeed costs to arrive at the total costs for the wintering operation.

Table 1. Whole or Ground Oats with Alfalfa Hay
for Growing Calves
(December 19, 1972 to July 10, 1973--203 days)
Experiment 1

	Whole oats	Ground oats
No. animals	57	56
Avg. initial wt., lb.	424	418
Avg. final wt., lb.	716	707
Avg. daily gain, lb.	1.44	1.42
Avg. daily feed, lb.		
Chopped alfalfa hay	15.7	15.6
Oats	5.0	5.0
Supplement	1.0	1.0
Total	21.7	21.6
Feed/100 lb. gain, lb.		
Chopped alfalfa hay	1090	1099
Oats	347	352
Supplement	69	70
Total	1506	1521

Table 2. Whole or Rolled Oats with Alfalfa-brome Haylage for Growing Calves (December 17, 1975 to May 14, 1976--149 days) Experiment 2

	Whole oats	Rolled oats
No. animals	13	13
Avg. initial wt., lb.	549	550
Avg. final wt., lb.	784	766
Avg. daily gain, lb.	1.57	1.45
Avg. daily feed, lb.		
Alfalfa-brome haylage	27.33 (13.67)[a]	25.43 (12.72)
Oats	5.92	5.92
Total	33.25 (19.59)	31.35 (18.64)
Feed/100 lb. gain, lb.		
Alfalfa-brome haylage	1733 (871)	1752 (877)
Oats	375	408
Total	2108 (1246)	2160 (1285)

[a]Values in parenthesis corrected to air dry or 88% dry matter basis.

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A.S. Series 76-15

Whole or Rolled Corn Grain Fed at Various Levels to Cattle on Pasture

L. B. Embry

Past experiments at this station with cattle on pasture have involved various levels of grain feeding. Levels of corn grain varied from none to a full feed averaging about 14 lb. per head daily. The corn was rolled prior to feeding in all experiments.

Several experiments have also been conducted where growing and finishing feedlot cattle were used in comparisons when feeding whole or rolled corn grain. Results of this research showed no advantage for rolling the corn in comparison to feeding whole on basis of weight gain and feed efficiency when rations contained 80% or more corn. At lower levels of grain feeding, there appeared to be some benefits from processing the grain.

Results of the feedlot experiments might indicate that corn grain need not be processed when offered at about a full feed to cattle on pasture. Therefore, experiments reported here were conducted to compare whole and rolled corn grain when fed at various levels to cattle during growing and finishing on pasture.

Procedures

The same pasture area was used for two experiments. It was established in 1968 and had been grazed at about maximum stocking rates each pasture season since that time. The pasture area was seeded for a stand of about equal parts alfalfa and grasses (bromegrass and intermediate wheatgrass). It was fertilized in early spring of most years with a typical application being about 125 lb. of 18-46-0 per acre. Management procedures appeared to maintain approximately the desired proportions of alfalfa and grasses in the pasture.

Levels of corn grain fed per head daily were 0 (control), 4 lb., 8 lb. and a full feed. Each level was replicated four times for 16 paddocks of cattle. For those fed grain, it was fed whole for two paddocks and rolled for the other two.

For the first experiment (1974), 64 Hereford-Angus heifers were allotted into 16 paddocks of 4 head each. For the second experiment (1975), 64 Hereford heifers were used again with four animals per paddock. Acres per replicate (paddock) provided were 5 for the no grain control and 4-lb. groups, 3.75 for the 8-lb. group and 2.5 for those full-fed.

Grazing procedures during the 2 years were to allow the cattle only one-half of each paddock for a period of about 6 weeks and then the entire area for the remainder of the grazing season. Because of relatively low rainfall during each year, the area of each paddock reserved for later grazing was not clipped nor were pastures clipped during the grazing season. Ample forage was available during the pasture season but with some on the mature side because of the management procedures followed.

Heifers in all paddocks fed grain were started at 4 lb. per head daily. The grain was increased at a rate of 1 lb. per head daily to the 8-lb. level for this group and until grain remained in the feed bunk at the next feeding for the full-fed group. Grain was fed once daily in feed bunks located near the water supply. Salt and dicalcium phosphate were supplied free-access. The heifers were implanted with 36 mg zeranol at the beginning of each experiment.

Results

Results of the experiment are presented in table 1. For most treatment groups, the Hereford-Angus heifers in the first experiment having a heavier initial weight had higher weight gains. The response in gain to increasing levels of grain feeding in comparison to the no grain control was quite small, amounting to 0.07, 0.05 and 0.07 lb. daily, respectively, for the 4 lb., 8 lb. and full-fed levels. Weight gains and response to grain feeding were less in these two experiments with heifers than in previous ones with steers.

There were no consistent differences between whole and rolled corn for levels of grain or years. The average for the 2 years showed only small differences in weight gain between forms of corn grain with no apparent advantage for processing the corn.

Summary

Results of the experiments show a relatively small response in weight gain per unit of grain by heifers fed grain on pasture at daily levels of 4 lb., 8 lb. or a full feed (about 14 lb.) in comparison to no grain controls. Rates of gain increased with increasing levels of grain and would, therefore, reduce days needed for drylot finishing following the pasture season.

Increasing levels of grain could be expected to reduce consumption of pasture forages which was not measured in these experiments. The decrease in forage consumption would mean more animals could be stocked per acre and could result in a lower pasture charge per animal.

These results differ somewhat from the drylot experiment where there appeared to be some advantage of rolled over whole corn at the grain levels used in these pasture experiments. An experiment in progress appears to be showing some advantage for rolled corn, even at the full-fed level. More pasture feeding experiments are planned to more adequately test the need for processing corn grain fed at various levels for growing and finishing cattle on pasture.

Table 1. Whole or Rolled Corn Grain Fed at Various Levels on Pasture

	No grain	4 lb./head daily		8 lb./head daily		Full-fed	
		Whole	Rolled	Whole	Rolled	Whole	Rolled
No. animals	27	16	16	16	16	16	16
Days fed	136	136	136	136	136	136	136
Initial shrunk wt., lb.	594	596	596	595	597	603	600
Final shrunk wt., lb.	759	798	794	816	813	914	884
Avg. daily gain, lb.	1.20	1.48	1.45	1.62	1.58	2.27	2.16
Avg. daily ration, lb.							
Whole or rolled corn		3.86	3.84	7.65	7.53	14.17	14.00
Feed/100 lb. gain, lb.							
Whole or rolled corn		260	266	472	475	625	650

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A.S. Series 76-16

Diethylstilbestrol, Synovex or Zeranol Implants for Finishing Steers

L. B. Embry and R. N. Gates

Numerous experiments during past years have shown that performance of growing and finishing feedlot steers and heifers is improved when they are administered diethylstilbestrol (DES), Synovex or zeranol. The improvement has been reported from an early age of the suckling calf throughout growing and finishing by implanting and reimplanting at appropriate intervals. Products available to be included in the feed include DES for steers and heifers and melengestrol acetate (MGA) for heifers. This route of administration is an effective one for improved weight gains and feed efficiency for these two products. Improvement in animal performance from these implants and feed additives has been reported with numerous types of rations as to levels and sources of energy, protein and other essential nutrients. However, the degree of response may vary with the nutritional adequacy of the ration.

Comparisons between DES, Synovex and zeranol implants and a nonimplanted control under various conditions of growing and finishing are more limited. The experiment reported here is a continuation of research comparing implants of the three products during feedlot finishing of steers.

Procedures

Steers used in the experiment were fed all-concentrate rations or similar rations plus 2 lb. of wheat straw or 2 lb. of bromegrass-alfalfa hay. Each type of ration was fed with 2 lb. per head daily of a soybean meal-based supplement (17% protein) or a corn-based supplement fortified with adequate levels of minerals, vitamin A, vitamin E and chlortetracycline. The three roughage treatments each with or without supplemental protein were offered to four pens of six steers per pen.

Within each of the six dietary treatments, one pen served as the non-implanted control, one pen of animals was implanted with 36 mg of DES, one with Synovex-S (20 mg estradiol and 200 mg progesterone) and one with 36 mg zeranol. Implant treatments were administered at the beginning of the 140-day finishing experiment. All steers had received 36 mg zeranol implants at the beginning of a growing experiment about 6 months prior to the start of this finishing experiment. A preliminary period of 6 weeks was allowed between this experiment and a previous growing experiment in which the ration was corn silage with protein supplement. Adaptation to an all-concentrate ration was accomplished during this preliminary period. The various dietary treatments were initiated when the cattle were weighed and sorted for the experiment.

Animals were allotted to 24 pens of 6 each on basis of weight. Feeding was once daily in amounts to be nearly consumed by the next feeding. The steers were confined to outside, concrete-paved pens without access to shade or shelter. Weights were taken at 4-week intervals in early morning before feeding. In addition, initial and final weights were taken following an overnight stand (about 17 hr.) without access to feed and water. The experiment was terminated after 140 days, animals marketed and carcass data obtained.

Results

There were no apparent interactions between dietary treatments and implant treatments. Therefore, results for implant treatments presented in the table are averages for six replications across dietary treatments.

Nonimplanted steers gained 2.80 lb. daily. All implant treatments resulted in faster weight gains. Differences over nonimplanted controls amounted to 0.15, 0.28 and 0.22 lb. daily for DES, Synovex-S and zeranol, respectively. Improvements expressed as a percentage over control in the above order amounted to 5.4, 10.0 and 7.9%. The differences shown for Synovex-S and zeranol over nonimplanted controls were significant (P<.05), but there were no significant differences between implant treatments.

Implant treatments appeared to have only small effects on feed intake. Therefore, implant treatments resulting in higher rates of gain also resulted in improved feed efficiency. The improvement as a percent of nonimplanted controls amounted to 6.9, 8.6 and 5.5%, respectively, for DES, Synovex-S and zeranol. All differences were significantly (P<.05) different from controls but not between implant treatments.

Differences in carcass characteristics measured were small. Implanted cattle making faster rates of gain had heavier carcasses with a tendency toward larger rib eyes and more fat covering.

Summary

Implants of 36 mg diethylstilbestrol (DES), Synovex-S (20 mg estradiol and 200 mg progesterone) and 36 mg zeranol and a nonimplanted control were compared in a finishing experiment using 144 steers averaging about 680 lb. initially with 6 pens of 6 each per treatment group. All steers had been implanted with 36 mg of zeranol about 6 months prior to the finishing experiment. Rations during the 140-day experiment were all-concentrates or similar ones plus 2 lb. of either wheat straw or bromegrass-alfalfa hay.

Nonimplanted steers gained 2.80 lb. daily. All implant treatments resulted in faster rates of gain. Improvements over controls amounted to 5.4, 10.0 and 7.9%, respectively, for DES, Synovex-S and zeranol. Implant treatments had only small effects on feed intake but resulted in improvements in feed efficiency of 6.9, 8.9 and 5.5% for DES, Synovex-S and zeranol, respectively. Differences in carcass characteristics were small. Implanted cattle making faster gains had heavier carcasses with a tendency toward larger rib eyes and more fat covering.

Implant Treatments for Finishing Cattle with High Corn Diets
(June 10 to October 23, 1975--140 days)

	Control	DES	Synovex-S	Zeranol
Number of animals	36	35[a]	36	36
Init. shrunk wt., lb.	680	683	679	679
Final shrunk wt., lb.	1071	1095	1110	1101
Avg. daily gain, lb.	2.80	2.95	3.08	3.02
Avg. daily ration, lb.	23.39	22.93	23.50	23.81
Feed/100 lb. gain, lb.	835	777	763	789
Hot carcass wt., lb.	664	679	688	683
Marbling[b]	6.3	6.2	5.8	6.0
Carcass grade[c]	19.9	19.7	19.6	19.5
Maturity[d]	23.1	23.0	22.8	23.0
Color[e]	4.9	4.9	4.7	4.7
Firmness[f]	5.8	5.7	5.7	6.0
Percent kidney fat	2.5	2.6	2.3	2.3
Rib eye area, sq. in.	11.16	11.16	11.42	11.46
Fat thickness, in.	0.66	0.72	0.71	0.70

[a]One loss occurred not believed to be related to conditions of the experiment. Results presented for this treatment group are for 35 head.
[b]Modest = 6, small = 5.
[c]Choice = 20, Good = 17. Graded to one-third grade.
[d]23 = A maturity.
[e]Higher number represents darker meat.
[f]Higher number represents firmer meat.

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A.S. Series 76-17

Conventionally-Dried, Solar-Dried and Acid-Treated Corn for Finishing Beef Cattle

R. M. Luther, L. B. Embry and J. F. Giles

Recent concern about costs and availability of energy for drying corn grain at harvest has led to a search for alternative methods of drying or preserving corn. The use of solar energy for drying or preservation with organic acids appear to be economical ways of handling wet corn in the storage structure. Limited information is available as to the nutritional value of corn subjected to these treatments and fed to fattening beef cattle.

An experiment was initiated at the James Valley Research and Extension Center, Redfield, during the summer of 1976 to determine the value of corn grain dried or preserved by different methods. A portion of the trial dealt with methods of administering vitamin A and these results will be reported at a later time.

Procedure

Seventy-eight crossbred steers averaging 750 lb. were purchased through a livestock auction for the experiment. The cattle were from one owner. The steers were ear tagged, weighed and allotted to 6 pens of 13 steers each. Initial and final weights were recorded following an 18-hour overnight stand without feed and water. The steers were vaccinated against IBR (Rednose) and Clostridium spp. (blackleg, malignant edema) and implanted with 36 mg zeranol at the start of the trial.

The ration treatments were methods of drying and/or preserving whole corn grain. Whole shelled corn harvested from the 1975 crop was stored in 1000-bushel quantities in separate bins.

Moisture content of corn at harvest was 24% for the solar-dried and 17% for the conventionally-dried corn and acid-treated corn. The corn was harvested between November 3 and 10. Differences in moisture content were due to corn varieties with differing maturity dates and dates of harvest. Conventionally-dried corn was dried with natural gas at a local elevator. Solar-dried corn was stored in an experimental bin designed for drying with solar energy and equipped with a fan and motor. The acid-treated corn was prepared by applying Grain Storer P at the rate of 1.3 gallon per ton (36 bu.). This product supplied propionic acid in an amount to permit safe storage up to 1 year. Acid-treated corn was stored in a granary bin of wood construction.

The cattle were fed chopped hay and oats grain for about a month prior to the start of the trial. During the first 2 weeks of the trial the cattle were gradually shifted to a full feed of whole shelled corn with limited hay. Hay consumption was reduced from 11.5 lb. to 2 lb. of good quality, chopped alfalfa-bromegrass hay per head daily during this period. Hay consumption over the 106-day trial averaged 2.67 lb. per steer daily. Each corn treatment was replicated with two pens of cattle. The cattle in one replication received 1 lb. of pelleted (1/4-inch) supplement containing ground corn, ground limestone, trace mineral salt and vitamin A to provide 20,400 International Units (IU) of vitamin A per steer per day. In the second replication, the cattle received no supplement but were allowed a free-choice mineral composed of ground limestone and trace mineral salt with added vitamin A to provide 34,000 IU per ounce. It was assumed, based on a previous experiment at this location, that the cattle would consume about 1/3 of an ounce of mineral (8 grams) for a daily intake of about 9,600 IU of vitamin A per steer daily.

Results

The results of the experiment are presented in table 1.

Table 1. Conventionally-Dried, Solar-Dried and Acid-Treated Corn for Finishing Steers (May 25 to September 8, 1976--106 days)

	Conventionally-dried corn	Solar-dried corn	Acid-treated corn
No. animals	26	25[a]	26
Avg. initial wt., lb.	776	773	776
Avg. final wt., lb.	1083	1071	1090
Avg. daily gain, lb.	2.90	2.81	2.96
Avg. daily feed, lb. (as fed basis)			
Whole corn	19.31	19.52	20.16
Chopped hay	2.67	2.67	2.67
Mineral	0.027	0.085	0.052
Total	22.007	22.275	22.882
Feed/100 lb. gain, lb.			
Whole corn	648	677	663
Chopped hay	92	95	90
Supplement	17	18	17
Mineral	1	3	2
Total	758	793	772

[a]One steer died of unknown causes.

Steer gains for the three types of corn were essentially the same with the gains of cattle fed solar-dried corn being only slightly lower than the other treatments. Cattle fed solar-dried corn and acid-treated corn consumed more feed than cattle fed conventionally-dried corn. Differences in feed required per unit of gain were small with the lowest requirements obtained with steers fed conventionally-dried corn.

The corn treated with propionic acid was at a lower moisture level than was desired for this treatment. Therefore, the benefits observed in feeding high-moisture corn, either untreated or acid-treated, which often result in improved feed efficiency over dry corn were not observed in this experiment.

The weather at this location during the feeding period was extremely dry, resulting in a natural decline in moisture content of the feeds fed. For example, the corn (all treatments) checked in early August contained 7 to 8% moisture. The whole corn appeared to be hard and tough and may have resulted in reduced consumption. However, corn consumption was in the order of 20 lb. per steer. A considerable quantity of whole corn kernels were observed to pass through the animals. The gains were in the order of 3 lb. per steer and this along with feed consumption indicate satisfactory performance for yearling cattle. Feed requirements of less than 8 lb. per pound of gain indicate efficient utilization of the whole corn.

Summary

A feeding experiment with yearling beef steers was conducted to compare the value of conventionally-dried corn, solar-dried corn and acid-treated corn. Steer gains were about the same for the three types of corn with the gains of cattle fed solar-dried corn being only slightly lower than the other treatments. Differences in feed consumption and feed efficiency between corn storage treatments were relatively small.

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A.S. Series 76-18

Effects of Method of Supplementing Vitamin A on Feedlot Performance and Blood and Liver Vitamin A Levels in Feedlot Cattle

R. M. Luther, L. B. Embry and J. F. Giles

Rations consisting of corn grain and limited hay appear to be satisfactory for fattening beef cattle from about 700 lb. to slaughter weights without additional protein supplementation. The intake of carotene, a precursor of vitamin A, could be relatively low under these conditions, and, therefore, a vitamin A supplement would likely be needed. In a previous experiment, pronounced signs of vitamin A deficiency became evident after about 6 months in cattle fed corn grain with about 4 lb. of a low-carotene hay and no supplemental vitamin A.

Methods other than through a daily supplement may provide a more practical and economical means of administration. Feeding vitamin A in a high potency supplement at 2- to 3-week intervals, in a free-choice mineral supplement or administering the vitamin as a large one-time injection offer certain convenience and labor saving advantages to the cattle feeder.

The objective of this experiment was to study the effects of method of administering vitamin A on the performance of feedlot cattle. The vitamin A status in terms of blood plasma level and liver storage was determined along with weight gain and feed efficiency in a trial conducted at the James Valley Research and Extension Center near Redfield during the summer and fall of 1975.

Procedure

Sixty-five Hereford steers averaging 735 lb. were purchased through a livestock auction for the experiment. The steers were from one ranch in central South Dakota. Wintering rations indicated liberal intakes of vitamin A and carotene. During a 60-day preliminary period prior to the start of the trial, the cattle were fed whole oats or corn grain with about 2 lb. of low quality, legume-grass hay. This low-carotene ration was expected to result in some depletion of initial body stores of vitamin A and carotene. Following this preliminary period, the cattle were ear tagged, weighed and allotted to 5 pens of 13 steers each. The steers were implanted with 36 mg zeranol at the start of the trial.

Experimental treatments were as follows:

1. Control--no vitamin A, mineral free choice
2. Conventional--daily supplement with vitamin A and mineral
3. Intermittent--vitamin A supplement top-dressed on the ration every 2 weeks, mineral free choice

4. No supplement--vitamin A in mineral free choice

5. No supplement--vitamin A injected at start of trial, mineral free choice

Each pen of cattle was given a full feed of whole shelled corn and 2 lb. of chopped average-to-poor quality alfalfa-bromegrass hay per head daily. The composition of the mineral mixtures and supplements with vitamin A is shown in table 1. The mineral mixtures were composed of ground limestone and trace mineral salt. The conventional supplement and the supplement fed intermittently were made into 1/4 inch pellets. The daily supplement (treatment 2) was fed at the rate of 1 lb. per steer daily. In the case of the top-dressed supplement (treatment 3), the cattle received the 1 lb. rate but with a level of vitamin A equal to 14 days of the daily feeding level at one time at the beginning of each 2-week period. For the injected group, vitamin A was administered by intramuscular injection at the beginning of the feeding period in the amount of 3 million International Units (IU). Free-choice mineral was placed in boxes equipped with a partial cover with vitamin A in the mix for treatment 4.

Table 1. Composition of Mineral and Supplement Mixtures

	Free-choice mineral mixture[a]		Vitamin supplements	
	Without vitamin A	With vitamin A	Conventional	Intermittent
	%	%	%	%
Ground corn	---	---	86.65	97.90
Ground limestone	74.43	74.42	10.00	---
Trace mineral salt	25.57	24.47	3.20	---
Vitamin A premix[b]	---	1.11	0.15	2.10

[a]Formula based on expected mineral consumption of 60 grams/head/day.
[b]Premix contained 15,000 IU vitamin A palmitate/gram by analysis.

The cattle were weighed initially and after 18 hours without feed and water at the start of the 145-day trial. Final weights were taken at slaughter following a 4-hour transit period. Samples of the supplements and feeds were collected periodically during the trial and analyzed for carotene and vitamin A.

Samples of blood were taken initially (July 16) and at 93 days (October 17) from the jugular vein. Blood and liver samples were collected when the cattle were slaughtered on December 9 (145 days). Carotene and vitamin A analyses were performed on all samples.

Average carotene content of the whole corn and feed supplements was 0.66 mg/pound. The poor-quality hay contained 0.70 mg carotene per pound. Vitamin A analyses were performed on the primary premix, supplements and the mineral mix at the State Chemical Laboratory, Vermillion.

The vitamin A primary premix was manufactured in 1974 with a listed concentration of 30,000 IU per gram. Analysis of the product revealed a concentration of about 15,000 IU/g following storage under atmospheric conditions for slightly more than 1 year. The analyzed concentration was used in calculating vitamin A concentration in the free-choice mineral mix and the supplements. Samples of the primary premix, supplements and the mineral mix taken later during the experiment indicated essentially no further loss in vitamin A potency from the initial concentrations. Studies have indicated substantial losses in vitamin A activity in primary premixes and mixed feeds following several months of storage. This would emphasize the importance of relatively fresh sources of feeds or that level of supplementation may need to be increased to take care of possible losses in activity.

Results

Feedlot Performance

Results of feedlot performance are presented in table 2. One pen of 12 steers is of limited value in evaluating effects of the method of vitamin A supplementation on weight gain and feed data. Variation in weight gains of considerable magnitude may exist between pens of this number when treated in the same manner. Other research has shown that weight gains of cattle fed rations low in vitamin A and carotene are not affected to any appreciable extent until body stores are essentially depleted and feed intake decreases.

Steers fed the ration without supplemental vitamin A gained at the lowest rate. They also had lower feed intake and thus the highest feed requirements.

Considerably higher rates of gain and greater feed intake were obtained when the ration was supplemented with a daily level of about 10,200 IU of vitamin A in a feed supplement. Weight gains and feed consumption would indicate no problem from lack of vitamin A even though the level fed was only about one-half of the recommended level for growing and finishing steers within the weight range in this experiment.

Cattle supplemented with vitamin A one time each 2 weeks, but at the same average daily level as those supplemented daily, had a lower rate of gain in comparison to those supplemented daily. Feed intake was also lower resulting in higher feed requirements.

Steers offered vitamin A in the free-choice mineral supplement received only a small amount of the vitamin (average about 1,200 IU daily) because of the low mineral consumption. They gained at a lower rate than steers supplemented daily but more than steers supplemented at 2-week intervals. They also had a lower feed intake than steers supplemented daily.

Steers injected with 3 million IU of vitamin A at the beginning of the experiment had similar performance as those supplemented daily. This amount of injected vitamin A was about twice the total units over the 145 days as for the daily supplemented group.

Table 2. Feedlot Performance and Methods of Vitamin A Supplementation (July 17 to December 8, 1975--145 days)

	Method of vitamin A supplementation				
	Control (None)	Daily supple-ment	Supplement at 2-week intervals	Free-choice in minerals	Injection 3 million IU
No. steers	13	12[a]	12[a]	12[a]	13
Avg. initial wt., lb.	735	739	738	738	734
Avg. final wt., lb.	1047	1167	1099	1127	1151
Avg. daily gain, lb.	2.16	2.95	2.49	2.68	2.88
Avg. daily ration, lb.					
Whole corn	16.95	19.20	18.25	18.94	19.51
Chopped hay	1.99	1.99	1.99	1.99	1.99
Supplement	---	0.993	0.076	---	---
Minerals	0.036	0.006	0.028	0.016	0.002
Total	18.976	22.189	20.344	20.946	21.502
Feed/100 lb. gain, lb.					
Whole corn	786	651	733	707	679
Chopped hay	92	67	80	74	69
Supplement	---	34	3	---	---
Minerals	2	0	1	1	0
Total	880	752	817	782	748
Avg. daily carotene intake, mg	12.6	14.7	13.5	13.9	14.3

[a]Losses from experiment unrelated to dietary treatments.

Blood and Liver Vitamin A and Carotene

Blood and liver vitamin A and carotene values for each treatment group are shown in table 3. Initial carotene values in blood plasma ranged from 54 to 78 mcg/100 milliliters. At subsequent bleedings, the carotene content of the blood was higher for each treatment group than that observed at the initial sampling. The highest values for plasma carotene were observed at the last sampling after 145 days on the low-carotene rations.

The carotene content of the rations (table 2) resulted in an average daily intake of about 1.5 mg per 100 lb. of average body weight during the experiment. This level represents about 25% of the recommended level to meet needs for vitamin A of growing and finishing cattle. Carotene levels in the blood are affected by dietary intake and values considerably in excess of those observed in this experiment are encountered with high-carotene rations. Liver carotene values obtained at slaughter would indicate low body stores. Initial liver storage was not determined.

Initial plasma vitamin A ranged from about 28 to 39 mcg/100 milliliters. Values of this magnitude are considered to represent adequate vitamin A nutrition. After 93 days, plasma vitamin A had dropped markedly (from 33 to

20 mcg/100 ml) in the control group and remained at this level during the remainder of the experiment. While a value of 20 mcg/100 ml is not generally associated with visible signs of vitamin A deficiency, these cattle had somewhat lower rates of gain and feed intake than those which received supplemental vitamin A. Liver vitamin A at slaughter for the control group indicates body storage was severely depleted.

A marked increase in plasma vitamin A values at 93 days resulted from the daily supplementation of about 10,200 IU. Values had decreased from the 93-day level after 145 days. The final plasma value and liver storage at slaughter would indicate that this level of vitamin A supplementation plus the small amount of ration carotene were sufficient to maintain adequate blood levels and body stores of the vitamin under conditions of the experiment. However, such values do not represent major liver storage of the vitamin.

Supplementing vitamin A at 2-week intervals in amounts to equal the same average daily level as daily supplementation gave similar results as measured by plasma levels and liver stores. Thus, blood and liver data indicated no appreciable difference between the two methods even though weight gains were lower for the cattle supplemented at 2-week intervals.

The low intake of the free-choice mineral supplement resulted in a low level of vitamin A supplementation (about 1,200 IU daily). While the plasma vitamin A level at 93 days was fairly high, there was a marked reduction after 145 days. This reduction along with the lower liver value in comparison to those for other vitamin A supplemented groups indicated the cattle were not receiving adequate amounts of vitamin A to maintain proper levels in the blood and body stores. Variable voluntary intake of free-access minerals would appear to be a serious disadvantage to this method of vitamin A supplementation.

Injection of vitamin A appeared to be an effective way of providing vitamin A. There was no major difference between this method and the daily supplementation as measured by blood values. However, the injected level was about twice the total level supplemented daily over the 145-day experiment. The higher injected level did result in larger liver stores at the end of the experiment.

Table 3. Blood Plasma and Liver Concentrations of Carotene and Vitamin A

Item	Control (None)	Daily supplement	Supplement at 2-week intervals	Free-choice in minerals	Injection 3 million IU
Blood carotene, mcg/100 ml					
July 16, 1975--initial[a]	54.15	57.00	62.58	64.00	77.69
October 17, 1975-- 93 days	87.31	120.92	115.42	136.42	119.08
December 9, 1975-- 145 days	112.31	146.58	113.83	123.50	145.23
Blood vitamin A, mcg/100 ml					
July 16, 1975--initial	33.28	27.78	28.06	30.26	39.28
October 17, 1975-- 93 days[b]	20.38	47.89	44.98	46.02	59.08
December 9, 1975-- 145 days[b]	20.90	35.12	36.12	25.78	39.80
Liver carotene, mcg/g[c]	2.39	2.48	2.10	3.02	2.81
Liver vitamin A, mcg/g[b,c]	0.78	3.43	4.67	1.71	5.63

[a]Significant difference between treatments (P<.05).
[b]Significant difference between treatments (P<.01).
[c]Collected at slaughter.

Summary

Yearling steers were fed a low-carotene ration during a 60-day preliminary period and a 145-day finishing experiment to compare methods of vitamin A supplementation. The experimental ration consisted of whole corn grain and 2 lb. per head daily of a low-carotene hay. The ration furnished an average of about 1.5 mg of carotene per 100 lb. of body weight during the experiment. This level of carotene was not sufficient to support adequate vitamin A nutrition as indicated by lower weight gains, less feed consumption and the plasma and liver vitamin A values at the end of the experiment in the group receiving no vitamin A.

Supplementing the ration with a daily level of 10,200 IU of vitamin A or an equivalent total amount but at 2-week intervals gave similar results as measured by plasma and liver vitamin A values. This level of vitamin A plus the small amount of ration carotene appeared to result in adequate plasma and liver vitamin A values under conditions of the experiment but without major liver stores.

Voluntary intake of a free-choice mineral supplement was quite low and cattle supplemented in this way received a low level of the vitamin. Blood and liver values at the end of the experiment indicated the method was unsatisfactory in comparison to other methods of supplementation. Variable voluntary intake of free-choice minerals would appear to be a serious disadvantage for this method of vitamin A supplementation.

Injection of 3 million IU of vitamin A at the beginning of the experiment maintained similar blood levels of the vitamin as daily supplementation even though the injected level provided about twice as much of the vitamin over the experiment. The higher level of vitamin A by injection did result in larger liver storage.

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A.S. Series 76-19

Aspen Material as a Feed Ingredient in Ruminant Rations

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Introduction

Aspen (Populus tremuloides), covering in excess of 58,000 acres in the Black Hills area and over 3 million acres in the Upper Great Lakes area, has not been harvested in sufficient amounts to perpetuate growth. Periodic harvesting is not only necessary to assure an aspen stand but younger trees are needed as a source of food for grouse, deer and other wildlife. Although aspen serves as a source of fiber for paper, lumber, insulation and other industrial uses, it is presently not used for these purposes in the Black Hills region. In all regions where aspen grows whether or not it has other uses, substantial stands have reached maturity (60 to 70 years old) and will die without production of replacement trees if harvesting programs are not initiated. South Dakota Department of Game, Fish and Parks is beginning such a program. In 1974 they were faced with the problem of utilization of harvested aspen trees. The purpose of this study was to determine the level at which the harvested aspen material could be fed to ruminants if corrected for known nutrient deficiencies such as protein and vitamin A. Of the hardwoods, aspen wood appears to have potential as a ruminant feed because of its low lignification (encrustation of fibers) and lack of known toxic constituents.

Materials and Methods

Approximately five acres of mature aspen were harvested near Sturgis, South Dakota, by the Department of Game, Fish and Parks consistent with accepted habitat improvement methods. The entire tree, including all branches, leaves and bark, was fed into a chipping device and blown into trucks for transporting to a drying bin near Egan, South Dakota. The dried chips were hammer-milled and directly incorporated into a complete pelleted ration. A ration containing 93% alfalfa served as the control. Five other rations were formulated using increasing levels of aspen at 12, 24, 32 and 48% of the total ration with the 48% level also being fed with 4% sodium hydroxide. Soybean meal (44% protein) was included in rations which contained aspen in a ratio of 40% soybean meal to 60% aspen. This ratio of soybean meal and aspen was used so that a soybean-aspen mix would approximate the alfalfa used as the control. The alfalfa used in this experiment contained 15% protein and the aspen material about 1% protein. Aspen material and soybean meal combinations then were used to replace 20, 40, 60 and 80% of the alfalfa in the control ration. All rations contained dried molasses, trace mineral salt, dicalcium phosphate and vitamin A. Four percent sodium hydroxide was added to one 48% aspen ration as a delignifying agent for aspen material. The ingredient composition is shown in table 1.

Table 1. Ration Composition, %

Ingredients	Control	12% aspen	24% aspen	36% aspen	48% aspen	48% aspen 4% sodium hydroxide
Alfalfa	93	73	53	33	13	13
Soybean meal	--	8	16	24	32	32
Aspen material	--	12	24	36	48	48
Molasses	5	5	5	5	5	5
Trace mineral	1	1	1	1	1	1
Dicalcium phosphate	1	1	1	1	1	1
Vitamin A[a]						
Estimated crude protein	14.88	15.20	15.52	15.84	16.16	16.16

[a]2,000 IU vitamin A per kg of ration.

Sixty Hereford steers weighing approximately 725 lb. were randomly allotted into 12 pens of 5 animals each. Each of the 6 rations was fed to 2 pens or 10 animals for a period of 93 days. All rations were fed as a complete pelleted ration on an ad libitum basis. Prior to the trial, animals were restricted to a ration of medium to poor quality mixed hay with no supplementation for a 3-week period. Animals were allowed approximately a 2-week period to reach full feed once the trial began. Animals were gaining about 0.5 lb. per day at this time. All experimental rations were well accepted and no intake problems were noted. Some difficulty was experienced in getting animals on full feed in one pen (5 animals) with the pelleted alfalfa control rations. Animals were off feed for a period of 2 days. Animals on all rations were fed an initial feed of 10 lb. per day and were increased by 10 lb. increments each day until full feed was achieved. Animals were weighed initially and at 32, 57 and 93 days. Initial and final shrunk weights were also obtained.

The amount of aspen available was sufficient to feed the steers for a period of 93 days. At this time, two steers from each pen (4 per treatment) were slaughtered for carcass data and taste panel evaluation of the meat. One steer from each pen (2 per treatment group) was used to conduct digestion and balance studies with the feedlot rations. The remaining 12 steers then were offered a high-concentrate finishing ration to determine effects of the previous experimental rations on later performance when fed typical high-concentrate finishing rations.

Results and Discussion

Growing and Finishing--Aspen Wood Phase

Feedlot Performance. Results of the 93-day feeding trial are shown in table 2. Differences between final filled and shrunk weights show a large amount of shrink (38 to 48 lb. per head) but with no apparent trend related to ration differences. Steers fed the control pelleted ration made a rather low rate of gain during the first 32 days of the experiment. Increasing levels of aspen with the soybean meal resulted in improvements in weight gains up to the level of 32% aspen and 24% soybean meal. The alfalfa in all rations was prepared from previously pelleted alfalfa and reground to prepare complete pelleted feed in each treatment. The alfalfa, having been ground twice in ration preparation, was quite fine and may have contributed to unusually low weight gains for the high alfalfa control during the first 32 days. The coarser aspen rations appeared to assist in getting animals to full feed sooner. After the first month weight gains were improved for the alfalfa control group. The average gain of 1.87 lb. daily for the remainder of the 93-day experiment more nearly represents expected gains from feeding pelleted alfalfa to cattle of the weight used in the experiment. In contrast to the increased weight gain for the alfalfa control group, steers in all groups fed soybean meal and aspen replacing various amounts of the alfalfa showed lower weight gains after the first month as the animals became heavier. Weight gains at 93 days would be influenced by differences resulting during any previous weight period.

Table 2. Feedlot Performance as Affected by Aspen Content of Diets

	Treatments					
Item	Control	12% aspen	24% aspen	36% aspen	48% aspen	48% aspen 4% sodium hydroxide
Number of animals	10	10	10	10	10	10
Number of days fed	93	93	93	93	93	93
Avg. initial filled wt., lb.	728	728	723	726	725	726
Avg. final filled wt., lb.	873	934	980	989	978	970
Avg. initial shrunk wt., lb.	708	705	702	702	704	704
Avg. final shrunk wt., lb.	826	893	937	951	930	931
Avg. daily gain, lb.						
32 days (filled)	0.94	1.48	3.16	3.56	3.27	3.63
57 days (filled)	1.69	2.90	3.52	3.32	3.17	3.16
93 days (filled)	1.55	2.23	2.77	2.83	2.72	2.62
93 days (shrunk)	1.26	2.02	2.53	2.68	2.42	2.44
Avg. daily ration, lb.						
32 days (consumption)	16.49	19.03	23.75	24.42	23.25	23.71
57 days	21.38	24.46	28.56	29.40	26.14	27.42
93 days	24.68	27.74	30.33	30.86	27.81	29.09
Feed/lb. gain, lb.						
32 days	20.31	13.54	7.53	6.88	7.12	6.58
57 days	15.63	10.26	8.08	9.04	8.31	9.59
93 days (filled)	15.93	12.49	10.95	10.95	10.25	11.12
93 days (shrunk)	19.50	13.80	12.07	11.66	11.56	12.03

Carcass Data. Carcass data for the 24 animals slaughtered after the 93-day growing period are shown in table 3. Usually animals of this weight class would not be desirable for slaughter. However, it seemed appropriate to obtain experimental data from each feeding phase. The animals did not have sufficient finish or marbling to receive high marbling scores or carcass grades as animals on finishing rations. Animals were graded from standard to good. No objectionable flavor was noted with any of the animals, however, and all animals received an acceptable taste panel evaluation score.

Table 3. Carcass Characteristics and Taste Panel Evaluation as Affected by Aspen Content of Diets

Item	Control	12% aspen	24% aspen	36% aspen	48% aspen	48% aspen 4% sodium hydroxide
Hot carcass wt., lb.	489.0	546.3	561.3	579.0	583.0	548.3
Dressing %	54.24	56.79	56.47	56.91	56.11	55.69
Federal carcass grade	standard	standard+	good-	good	standard+	standard+
Marbling score	2.8	3.0	3.8	3.8	3.3	3.3
Abscessed livers	1	--	--	--	--	--
Rib eye area, cm^2	69.48	79.42	76.66	73.13	77.63	76.48
Confirmation	17.8	19.0	19.3	19.5	19.0	19.3
Maturity	23.0	23.0	23.0	23.0	23.0	23.0
Color	3.5	3.8	5.3	5.0	3.8	4.8
Firmness	5.0	4.8	5.8	5.5	5.3	5.3
Kidney fat, %	1.9	1.8	2.9	2.2	1.9	2.1
Taste panel evaluation[a]						
Tenderness	3.82	3.48	3.23	4.03	3.03	2.80
Flavor	3.43	3.25	3.13	3.43	3.18	3.00
Juiciness	3.90	3.80	3.53	3.98	3.58	3.10

[a]Scored on a scale of 1 to 5 with lower values being more desirable.

Finishing Phase--Standard Rations

Feedlot performance for 24 of the animals that were continued on a finishing ration (85% corn, 15% mixed alfalfa-brome) is shown in table 4. Animals fed the control ration were lighter than animals provided all other rations at the beginning of this period because of lower gains during the growing phase. Control animals appeared to compensate by making somewhat better gains during the 85-day finishing phase but were still lighter in weight at the termination of the trial than animals on the other treatments.

Carcass characteristics and grade did not appear to be greatly influenced by previous rations (table 5).

Table 4. Feedlot Performance with Standard Finishing Diets

Item	Previous treatments					
	Control	12% aspen	24% aspen	36% aspen	48% aspen	48% aspen 4% sodium hydroxide
Number of animals	4	4	4	4	4	4
Number of days fed	85	85	85	85	85	85
Avg. initial filled wt., lb.	847.5	877.5	964.8	946.0	918.7	848.5
Avg. final filled wt., lb.	1096.5	1124.8	1159.5	1161.5	1169.0	1164.5
Avg. initial shrunk wt., lb.	791.0	837.5	927.3	912.3	873.0	909.0
Avg. final shrunk wt., lb.	1064.5	1100.0	1139.8	1128.3	1135.0	1130.5
Avg. daily gain, lb.						
33 days (filled)	4.02	3.70	1.84	2.67	2.86	3.02
61 days (filled)	3.03	3.17	2.55	2.62	3.02	2.86
85 days (filled)	2.93	2.91	2.29	2.54	2.95	2.54
85 days (shrunk)	3.22	3.09	2.50	2.54	3.08	2.61
Avg. daily ration, lb.						
33 days (consumption)	22.16	21.37	23.29	22.72	22.01	23.94
61 days	24.65	23.89	23.99	25.20	24.09	24.10
85 days	25.41	24.77	25.16	26.23	26.39	25.15
Feed/lb. gain, lb.						
33 days	5.50	5.78	12.65	8.52	7.70	7.92
61 days	8.13	7.53	9.39	9.62	7.99	8.44
85 days (filled)	8.57	8.51	10.98	10.35	8.96	9.89
85 days (shrunk)	7.86	8.08	10.14	10.39	8.62	9.72

Table 5. Carcass Characteristics and Taste Panel Evaluation with Standard Finishing Diets

Item	Previous treatments					
	Control	12% aspen	24% aspen	36% aspen	48% aspen	48% aspen 4% sodium hydroxide
Hot carcass wt., lb.	623.3	659.8	697.0	692.3	683.3	681.0
Dressing %[a]	58.59	59.97	61.14	61.41	60.20	60.24
Federal carcass grade	choice-	choice-	choice-	choice-	choice-	choice-
Marbling score	4.9	5.1	6.3	5.5	6.2	4.6
Abscessed livers	--	--	--	--	--	--
Rib eye area, cm^2	62.89	65.63	72.15	72.55	73.83	72.20
Confirmation	20.0	20.5	20.8	20.5	21.0	20.3
Maturity	23.0	23.0	23.0	23.0	23.0	23.0
Color	5.0	5.0	5.0	5.0	5.0	5.0
Firmness	5.8	4.8	5.8	5.5	5.0	5.3
Kidney fat, %	2.0	2.5	2.5	2.4	2.3	2.3
Taste panel evaluation[b]						
Tenderness	3.4	2.8	--	--	3.4	3.2
Flavor	2.5	2.4	--	--	2.6	2.6
Juiciness	3.45	3.20	--	--	3.40	3.35

[a]Determined on basis of hot carcass weight.
[b]Scored on a scale of 1 to 5 with lower values being more desirable.

Digestion and Metabolism Trial

Twelve of the animals (two from each treatment) were used in the digestion and metabolism trial. The summary of the results appears in table 6. Rations having higher apparent digestibility for the various nutrient components were also those which were associated with higher gains and feed efficiency. In general, soybean-aspen rations in this ratio were more digestible. This was indicated with all nutrients except ether extract which is a minor component in these rations.

Table 6. Digestion and Metabolism Trial on Aspen Wood Rations--Dry Matter Intake, Digestibility Coefficients and Mineral Balance

Item	Control	12% aspen	24% aspen	36% aspen	48% aspen	48% aspen 4% sodium hydroxide
Dry matter intake/100 kg body wt., kg	2.19	2.25	2.11	2.20	1.86	2.30
Apparent digestibility, %						
Dry matter	51.51	51.15	54.46	59.45	62.85	57.06
N.F.E.	59.86	63.28	59.81	67.23	68.93	61.94
Crude protein	46.71	55.13	63.64	70.73	76.64	68.63
Crude fiber	34.27	34.70	43.57	43.70	50.40	44.24
Ether extract	84.43	88.04	87.41	73.61	74.45	69.72
TDN, %	49.59	53.12	55.49	59.46	63.41	54.96
D.E., Mcal/day	14.80	18.16	18.38	22.42	20.23	21.19
Nitrogen balance						
Total intake, g/day	111.0	148.1	151.2	196.0	166.9	196.1
Retention						
Grams/day	51.4	80.2	94.8	136.5	126.4	132.4
Percent of intake	46.3	54.2	62.7	69.6	75.7	67.5
Mineral balance, g/day						
Calcium	24.10	18.02	17.48	22.62	25.38	13.20
Phosphorus	9.93	6.78	0.53	4.13	9.15	3.71

The reliability of using only two animals from each treatment for the digestion and metabolism trial could be questioned. When used in conjunction with the feedlot performance, it can be used as substantiating data to indicate trends which might be expected.

Economic Considerations

Cost of Aspen Material, Processing and Ration Preparation. A thorough cost analysis is difficult during initial phases of feasibility studies. Three cost analyses were made, however, during this first experimental trial in aspen utilization to determine the cost of harvesting and preparation of whole aspen tree material into a feed. The first cost analysis was made by the Department of Game, Fish and Parks in 1975 (table 7).

Braden Forestry Services Incorporated, Deadwood, South Dakota, was contracted to make a more extensive cost analysis of processing aspen material prior to its incorporation into animal rations. Although the entire cost analysis is too voluminous to include in this report, the essential costs per unit of production for a simulated model operation in the Black Hills are estimated in table 8.

Total Tree Incorporated, Burnsville, Minnesota, also made a cost analysis of processing aspen prior to ration preparation. This cost analysis is based on actual commercial production of aspen in volumes of 800 tons of aspen daily. Note that the analysis does not include grinding or drying of aspen, only production of wet chips loaded into 22.5 ton vans.

The cost analysis of production of wet chips in Minnesota was made on August 19, 1976, and thus should still reflect near present-day costs. If a drying and grinding charge of approximately $10 was added to wet chip production costs, prepared aspen for ration forumulation should cost on a commercial basis approximately $18.50 per ton. Both cost analyses made for the Black Hills area estimated the cost of processed aspen to be from $35 to $42 per ton.

The economic analysis of costs during experimental development of a feeding program are probably not realistic since the main objective is to determine feasibility in initial trials rather than the most economical method. This is shown by the comparison between experimental costs of harvesting aspen in the Black Hills versus the suggested commercial costs indicated by a commercial company (Total Tree Inc.).

When ration preparation from the processed aspen product is considered, the same thinking prevails. The amount of soybean meal needed to completely replace alfalfa would usually be too costly under usual price relationships between soybean meal and hay. In order for such a product to compete on the basis of cost, it would require a cheaper source of protein and energy than soybean meal. This does not defeat the objective of the feasibility study--to show whether or not it is possible to produce a product which would have similar animal utilization to alfalfa if made equal in basic nutrients. Other avenues for uses also become apparent, such as using a product which is well accepted by animals but lacks protein or other nutrients to dilute a

Table 7. Comparative Cost Data, 1975 Aspen Feeding Trial

Cost item	Cost/ton in dollars	Cost/lb. in cents	Cost per ton in dollars: Control	12% level	24% level	36% level	48% level
Harvesting and chipping	20.50	0.01	0	2.40	4.80	7.20	9.60
Drying	18.60	0.009	0	2.16	4.32	6.48	8.64
Grinding	1.90	0.009	0	0.22	0.44	0.66	0.88
Subtotal							
(1) Cost of aspen portion of the ration	41.00	0.0205	0	4.78	9.56	14.34	19.12
(2) Pelletizing and bagging	18.00	0.009	18.00	18.00	18.00	18.00	18.00
(3) Cost of the additive portion of ration			97.75	96.75	89.00	81.70	75.20
Total ration cost (sum of items 1-3)			115.75	119.53	116.56	114.04	112.32
Ration cost/lb.			0.58	0.060	0.058	0.057	0.056
Ration cost/lb. of gain (shrunk wt.)			1.13	0.83	0.70	0.66	0.65

Table 8. Unit Production Costs for Model Operation

Item	Dollars per ton dried chips
1. Timber purchase and acquisitions, including road building and maintenance	1.73
2. Falling and bunching of trees	9.70
3. Transportation of rough logs to central chipping and drying plant	6.93
4. Chipping process (including handling of chips to drying process)	7.36
5. Drying process (including handling of chips to storage area or loading for distribution to pelleting plant)	4.50
6. Business administration, overhead and profit margin (Profit margin computed here in 12% return on investment of capital, equipment, labor and management)	5.29
Total unit production costs	$35.51

Note: Amortization and depreciation of capital equipment are included within the cost figure for each operational phase.

traditional feed which possesses a surplus of nutrients for a certain feeding program. For example, it may be desirable to dilute corn silage for breeding animals being wintered to prevent excessive finish while saving on feed costs.

Summary and Conclusions

Aspen wood material and soybean meal in a ration of a 60:40 ratio resulted in faster rates of gain through 93 days. These ratios result in a final product comparable to good quality alfalfa. The percentage of soybean meal contributes substantially to the energy as well as the protein of the mixture. The mixture ratio appears to be equivalent in energy to the control ration as determined by the digestion trial. The results show, in general, that soybean and aspen mixtures were a satisfactory substitution for up to 80% of the alfalfa in the control ration.

Aspen steaks, from both the growing and finishing phase, were rated quite similar by the taste panel, both being acceptable with no off-flavor noted. Fat deposition in the animals which completed the finishing phase appeared somewhat abnormal. Fat was deposited in layers rather than the usual expected marbling patterns. This could have been caused by the high weight of some of the animals prior to the finishing phase.

The economic importance of utilizing aspen will depend on several factors, such as the market price of traditional feeds, the cost of harvesting and transporting aspen from its source and cheaper ways to supplement the aspen material to correct nutritional deficiencies.

Additional experiments are now in progress in which aspen serves as the roughage portion of finishing rations. An attempt is also being made to use forms of nitrogen other than soybean meal to decrease cost. Chicken manure as a source of supplemental protein is presently being investigated.

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Effects of Monensin on Dietary Protein Needs and Nonprotein Nitrogen Utilization by Growing Feedlot Cattle

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Monensin has been shown to improve feed conversion by cattle when fed with a number of different feedstuffs in various types of rations. The resulting changes in rumen fermentation would suggest that the product might have a protein sparing effect and could improve the utilization of nonprotein nitrogen compounds such as urea.

The objectives of this experiment were to study the possible protein sparing effects of monensin in a growing ration composed primarily of corn silage and to determine its effects on the utilization of urea.

Procedures

One hundred ninety-two Hereford steer calves were purchased at a local auction for this experiment. After arrival at the feedlot, all animals were fed corn silage to appetite and a corn supplement with added minerals and vitamin A for 6 to 7 weeks before the trial was begun. No supplemental protein was fed before the experiment was initiated. All steers were treated with a pour-on grubicide and implanted with Synovex-S near the beginning of the experiment.

Following adaptation to feedlot conditions, the steers were weighed in early morning before feeding for an initial filled weight and again following an overnight stand without access to feed and water for an initial shrunk weight. The average initial shrunk weight was 495 pounds. Allotment based on shrunk weights was made at random within weight groups of 24 pens of 8 head each. Intermediate weights were taken at 21 days and every 4 weeks thereafter. Filled and shrunk weights were obtained in the same manner as initially at the termination of the 116-day growing experiment.

The steers were confined to outside, concrete-paved pens with water available from automatic waterers. They were fed corn silage and a top-dressed grain-supplement mixture.

The corn silage contained an average dry matter content of 32.8% and 10.4% protein, dry basis. Grain yield of the corn was low because of drought conditions during the crop year. The amount of grain in the silage determined by separating samples at harvest into chopped forage and grain was 24% of the dry weight.

In order to have rations more typical of silage from well-eared corn, the grain-supplement mixtures were fed in ratios with the silage to give silage with grain an equivalent of 50% of the dry matter. This amounted to a 34% grain-supplement mixture and 66% silage on a dry basis. As fed, the grain-supplement mixtures comprised 18% of the rations and corn silage the remaining 82%.

Three grain-supplement mixtures as follows were fed with corn silage:

1. Corn control
2. Corn-soybean meal
3. Corn-urea

Each grain-supplement mixture was fed with and without monensin to give six dietary treatments. Four pens each with 8 steers were fed each of the six rations.

The control grain-supplement mixture was composed of rolled corn grain with added ingredients to provide rations adequate in salt, calcium, phosphorus, trace minerals and vitamin A. Soybean meal or urea was included in the other grain supplements to test the need for supplemental protein and to compare the two sources in rations with and without monensin. Some adjustments were made in ingredients to provide rations similar in calcium, phosphorus and trace mineral contents. The monensin was added at 10 g/ton of air dry ration for the first 21 days and at 30 g/ton thereafter. Ingredient composition of the grain-supplement mixtures is shown in table 1.

Results

Feedlot performance is presented in table 2. The data are presented accumulated to date by weigh periods to show the effects of various treatments during the course of the experiment.

It was desired that the rations without supplemental protein be borderline or slightly deficient in protein while those supplemented with soybean meal or urea contain more than commonly recommended requirements. Average protein content of the rations without supplemental protein (corn) was about 10.5%. This is less than recommended requirements for growing-finishing steers up to about 750 lb. for gains of 2.5 lb. daily. Protein levels were increased approximately 2.8 and 2.2 percentage units by soybean meal or urea supplementation.

Feed Consumption

Feed consumption increased with increasing weights and time on experiment for all treatment groups. Without monensin, there appeared to be no effect of level of protein or the supplemental source on feed consumption.

Monensin depressed feed consumption with all supplements. During the first 21 days of the experiment when the level was 10 g/ton of air dry feed, the decrease in comparison to the no monensin controls amounted to 9.8, 8.6 and 11.2%, respectively, for the corn, soybean meal and urea supplements. There was essentially no change from this initial depression with the soybean meal supplement (9.0%) at the end of the experiment (30 g/ton after 21 days). The depression in feed intake was slightly greater for the total experiment with the corn supplement (14.7%) and the urea supplement (14.3%).

Weight Gain

Weight gains were exceptionally good for the rations fed. This likely can be attributed in part to the supplemental grain added to result in rations with about 50% of the dry matter as grain. The 116-day experiment was between weights of approximately 500 to 800 pounds. Rates of gain no doubt would have been at lower rates if the cattle had been continued on the rations for a longer period and to heavier weights.

Without monensin, comparisons between corn and soybean meal supplements indicate a beneficial effect from protein supplementation throughout the experiment. However, feeding urea resulted in an initial depression in weight gain in comparison to no supplemental protein. The cattle fed urea had more than compensated for this initial depression at the 49-day weight. Average daily gain exceeded the corn group at most periods after 21 days, and they had slightly higher gains upon termination of the experiment. The difference in average daily gain upon termination of the experiment between steers supplemented with soybean meal or urea resulted largely from the apparent initial depression from urea. The results indicate a need for supplementing the corn ration (10.5% protein, dry basis) with additional protein. There appeared to be little difference between soybean meal and urea after the initial 3 weeks of the experiment.

Monensin appeared to depress weight gains during the first 21 days of the experiment (10 g/ton feed) for steers fed the corn or urea supplements but not with soybean meal. Over the entire experiment, weight gains were essentially the same with and without monensin when steers were fed the soybean meal supplement. Gains were slightly more with monensin for those fed the corn (5.0%) or urea (4.0%) supplements.

Feed Efficiency

Treatment differences in weight gain and feed consumption during the initial 21 days of the experiment would have pronounced effects on feed requirements during this short period as shown in table 2. Since feed efficiency is a calculated value from feed consumption and weight gain, it is discussed only for the overall experiment on basis of shrunk weights.

Without monensin, protein supplementation improved feed efficiency. The improvement over the corn supplement treatment amounted to 11.4% for soybean meal and 5.4% for urea. As indicated for weight gain, the difference between soybean meal and urea would have resulted largely from a difference in performance during the first 21 days of the experiment.

Feed efficiency was improved with monensin. The improvement over no monensin amounted to 18.7, 9.9 and 17.0%, respectively, for steers fed corn, soybean meal and urea supplements. However, the advantage in feed efficiency from protein supplementation when rations contained monensin amounted to only 1.8% for soybean meal and 4.6% for urea.

Summary

Steers were fed a corn silage ration with added corn grain to provide about 50% grain in the silage dry matter (10.5% protein, dry basis) from weights of about 500 to 800 lb. (116 days). The rations were also supplemented with protein from soybean meal or urea with all comparisons being made with and without monensin.

Without monensin, supplemental protein had no apparent effect on feed consumption. Monensin at 10 g/ton of air dry feed for 21 days and then 30 g/ton reduced feed intake. The reduction amounted to 14.7, 9.0 and 14.3%, respectively, with corn, soybean meal and urea supplements.

Average daily gains were higher when rations contained supplemental protein. The advantage for soybean meal and urea over the corn supplement in rations without monensin amounted to 12.0 and 6.7%, respectively. The difference between soybean meal and urea resulted largely from the depression from urea during the first 21 days of the experiment. Steers fed monensin had slightly higher weight gains when fed the corn supplement (5.0%) and the urea supplement (4.0%) but essentially unchanged when fed soybean meal.

Without monensin, protein supplementation improved feed efficiency. The improvement over the corn supplement was 11.4 and 5.4%, respectively, for soybean meal and urea. As for weight gain, the difference between soybean meal and urea resulted largely from the initial depressed performance with urea.

Feed efficiency improved with monensin amounting to 18.7, 9.9 and 17.0%, respectively, with corn, soybean meal and urea supplements. Improvement in feed efficiency was less for protein supplementation when rations contained monensin but greater with urea than with soybean meal.

Results of the experiment indicate that monensin improves protein utilization when fed in rations slightly deficient in protein and that it results in improvement in utilization of nonprotein nitrogen from urea.

Table 1. Supplement Formulation--Monensin With Corn, Urea or SBOM Supplements for Calves Fed Corn Silage

Ingredient, %	Corn supplement	Soybean meal supplement	Urea supplement
Corn grain	95.69	75.71	92.82
SBOM	--	20.41	--
Urea	--	--	2.53
Limestone	1.70	1.73	1.30
Cyphos	1.66	1.26	1.72
Calcium sulfate	--	--	0.68
Trace mineral salt	0.89	0.89	0.89
Trace mineral premix	0.06	--	0.06
Vitamin A premix (30,000 IU/g) added at the rate of 9.8 g/100 lb. supplement			

Monensin primary premix (30 g/lb.)
added only to treated supplements at the rate of 24.8 g/100 lb. supplement for rations with 10 g/ton air-dry ration and at 74.4 g/100 lb. supplement for rations with 30 g/ton air-dry ration.

Table 2. Protein Levels and Sources with Monensin for Growing Cattle (January 30 to May 25, 1976--116 days)

	Corn supplement		SBOM supplement		Urea supplement	
	Control	Monensin	Control	Monensin	Control	Monensin
No. animals	32	32	32	32	32	32
Init. shrunk wt., lb.	496	495	496	497	494	494
Final shrunk wt., lb.	774	787	808	812	792	801
Avg. daily gain, lb.						
21 days	3.27	2.22	3.50	3.69	2.75	2.34
49 days	2.72	2.68	3.24	3.21	3.15	2.62
77 days	2.47	2.50	2.88	2.96	2.47	2.60
105 days	2.54	2.55	2.79	3.01	2.64	2.67
116 days (filled)	2.53	2.68	2.84	2.95	2.75	2.78
116 days (shrunk)	2.40	2.52	2.69	2.72	2.56	2.65
Avg. daily ration, lb.						
21 days	30.56	27.56	30.71	28.07	31.46	27.95
49 days	32.79	28.56	32.69	29.20	32.58	28.00
77 days	33.93	29.23	34.18	30.91	33.72	29.28
105 days	37.27	31.76	37.38	33.75	37.24	31.58
116 days	38.34	32.69	38.07	34.63	38.24	32.79
Feed/100 lb. gain, lb.						
21 days	936	1243	878	760	1154	1212
49 days	1208	1066	1010	909	1036	1069
77 days	1374	1169	1189	1045	1367	1126
105 days	1466	1246	1341	1122	1413	1183
116 days (filled)	1514	1219	1340	1173	1391	1181
116 days (shrunk)	1598	1299	1416	1276	1492	1239

CORN SILAGE: INFLUENCE OF AMOUNTS, FEEDING SYSTEMS AND DROUGHT-DAMAGE ON FEEDLOT PERFORMANCE

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Corn silage is a highly palatable feed that fits well into many types of rations and feeding programs. Cattle fed rations which contain corn silage are easy to keep on feed and because of the moderate level of available energy in corn silage they perform better than cattle fed other forages. It is understood that corn silage does not contain sufficient amounts of crude protein, calcium, phosphorus and sodium chloride to meet the requirements of feedlot cattle. Thus, corn silage rations are routinely supplemented with these nutrients and few producers question the need for supplementation or the amount of nutrients that should be provided when rations that contain corn silage are fed. Of much more concern to cattle feeders is the influence of amount of corn silage on feedlot performance and economic returns. Especially since grain prices have increased and many acres have been harvested as silage due to the drought, cattle feeders have expressed an interest in feeding higher corn silage rations. However, cattle fed high corn silage rations gain slower and consequently they must be fed for longer periods than cattle fed high grain rations. This results in increased nonfeed costs. This paper will examine the influence of silage level, systems for feeding corn silage and drought-damaged corn silage on the performance and economic returns of feedlot cattle.

Influence Of Corn Silage Level On Feedlot Performance

Data from 17 university experiments that involved 878 steer calves were analyzed using regression techniques. The data were obtained from Ohio, South Dakota, Illinois, Michigan and Purdue feeders day reports. Feedlot performance at eight corn silage levels was predicted using the regression equations developed from the feeding trial data. The data which were predicted from the regression equations and economic calculations based on these data are presented in table 1.

1. Daily gain declined from 2.52 lb to 1.91 lb as silage level increased from 10 to 80% of the ration dry matter. The decline in daily gain for each 10 percentage units increase in corn silage level was greater at high silage intakes than at low corn silage intakes. For example, daily gain declined from 2.05 to 1.91 lb per day as the amount of silage was increased from 70 to 80%, but daily gain declined from 2.52 to 2.49 lb as the silage level increased from 10 to 20%.

2. Maximum dry matter intake occurred when the ration contained 40 to 50% corn silage dry matter.

3. Amounts of feed dry matter per 100 lb of gain increased 26 lb for each 10 percentage units increase in corn silage dry matter.

4. In an attempt to determine the corn price at which rations high in corn silage should be fed, the following calculations were made:

   a. Cost/ton of corn silage.

      Average corn silage contains about 50% corn grain dry matter. Thus, there are 6.7 bu of No. 2 corn per ton of silage at 68% moisture. Addition of \$3 per ton to allow for added storage, handling and harvest costs results in the following equation:

      Cost/ton at 68% moisture = 6.7(X) + \$3.00

      where X equals the cost per bushel of No. 2 corn grain.

   b. Value of corn silage.

      Feed efficiency and nonfeed cost data from table 1 were used to develop the following equation:

      Value/ton at 68% moisture = 9.48(X) - cost of 15.7 lb supplement DM - \$1.35

      where X equals the cost per bushel of No. 2 corn grain.

      This equation was developed from amounts of corn silage, corn grain and supplement per 100 lb of gain and nonfeed costs per 100 lb for farmers that feed one lot per year when rations containing 10 or 80% corn silage were fed. If supplement is priced at \$10/100 lb of dry matter, the equation becomes:

      Value/ton at 68% moisture = 9.48(X) - \$1.57 - \$1.35
      = 9.48(X) - \$2.92

   c. The cost of corn silage was then set equal to the value of corn silage to determine the price at which the cost of corn silage equals the value of corn silage:

      6.7(X) + \$3.00 = 9.48(X) - \$2.92
      X = \$2.13

   Thus, when corn grain costs less than \$2.13 per bushel the value of corn silage is less than the cost of corn silage and farmers that feed one lot per year should feed high grain rations. Likewise, when corn grain costs more than \$2.13 per bushel, high silage rations should be fed. This is illustrated by values presented in table 2.

These calculations are based on average nonfeed costs. Farmers with lower than average nonfeed costs should change from high grain to high silage rations at a corn price somewhat less than \$2.13 per bushel. Also, farmers with high nonfeed costs should continue to feed high grain rations even though corn costs more than \$2.13 per bushel. For example, if nonfeed costs are half those considered herein the point of change to high silage rations would be a corn grain price of \$1.89 per bushel. If nonfeed costs are twice those considered herein, because of new facilities or higher than normal labor or interest costs, the point of change to high silage rations would be a corn grain price of $2.62 per bushel.

Another factor that may influence the corn grain price at which the ration should be changed from one composed largely of corn grain to one composed of large amounts of corn silage is the possibility that cattle fed high corn silage rations may need to be fed to heavier weights to grade Choice than cattle fed high grain rations. Goodrich and Meiske (1974) noted that Holstein steers fed high grain rations were fatter than steers fed high silage rations when the cattle were compared on an equal carcass weight basis. In contrast, others (Guenther et al., 1965; Berg and Butterfield, 1968; Winchester and Howe, 1955; Winchester and Ellis, 1956) have reported data which suggest that carcass composition is not greatly influenced by the energy content of the ration and that carcass weight has a greater influence on carcass composition than does age. If cattle fed high corn silage rations are fed to heavier weights, whether this is necessary or done because it is usual practice, the price of corn grain at which high corn silage rations should be fed would be considerably higher than $2.13 per bushel.

The rates of gain and feed efficiencies reported herein are based on shrunk final weights. Adjustments for differences in dressing percentages were not made because several studies did not report dressing percentage values. It is likely that cattle fed the higher corn silage rations had lower dressing percentages than cattle fed the higher grain rations. Thus, the rates of gain and feed efficiencies probably are more favorable for cattle fed the high silage rations than they should be. Dressing percentage adjustment of the data would likely result in a higher corn grain price at which the ration should be changed from high grain to high silage.

A final consideration is the influence of silage level on the date at which the cattle would be marketed. This is illustrated in table 3. The $2.13 per bushel corn price does not consider changes in market price which may occur between the time cattle fed high grain rations are marketed and the time that those fed high silage rations are marketed. If the market price were to drop $2.00 per 100 lb of live weight during the period that high grain and high silage cattle would be marketed, a ton of corn silage would need to be given an additional negative value of $3.74. This would result in a corn grain price of $3.47 at which the ration should be changed to high silage. Likewise, if the finished cattle price were to increase by $2.00 per 100 lb, corn silage would have an increased value. In this instance, the point of change from high grain to high silage rations would be $0.78 per bushel. Thus, it is obvious that one of the most important factors that influences the decision to feed high grain or high silage rations is the effect of ration on market date and the change in market price that may occur during the period when cattle fed high grain or high silage ration would be marketed.

Farmers who keep their lots full continuously should continue to feed high grain rations at higher corn grain prices than farmers who feed one lot per year. This is because nonfeed costs per animal are increased to a greater extent as silage level increases when cattle are fed continuously. Also, when gross margins are large and the profitability of cattle feeding increases, the corn grain price at which the ration should be changed from high grain to high silage increases. This is because total profit (profit per head times the number of head fed per year) will more likely be maximized by feeding more cattle (rapid turn-over rate) than by feeding fewer cattle at maximum profit per head. Thus, an indication of the corn grain price at which the ration should be changed from one based largely on grain to one based largely on silage can be stated only when one lot of cattle is fed per year.

Systems For Feeding Corn Silage

Most cattle feeders have feedlots with established animal capacities and limited corn silage storage facilities. Thus, when the corn silage facilities are filled and a given number of cattle are placed in the feedlot, the amount of corn silage that will be fed per animal has been set. The obvious question is then, what is the best system for feeding a given amount of corn silage to a given number of cattle?

The cattle could be fed a constant amount of corn silage for the entire feeding period; they could be fed a large amount during the growing phase and a small amount during the finishing phase (two-phase feeding); they could be fed a gradually decreasing amount of corn silage or they could be fed a ration with a constant corn silage:corn grain ratio (this results in a gradually increasing intake of corn silage since the cattle consume more corn silage as well as more corn grain as they get heavier). Two trials were conducted to compare these four systems for feeding equal total amounts of corn silage:

Treatment no.	Silage feeding program	Description of program
1	Constant amount	Corn silage at 15 lb/head daily during the entire 238-day feeding period.
2	Two-phase	Corn silage fed at 25 lb/head daily for the first 114 days, and at 5 lb/head daily during the last 114 days, with a 10-day period for the switch-over in the middle of the period.
3	Gradually decreasing	Corn silage fed at 25 lb/head daily for the first 2 weeks and then decreased 1.25 lb/head daily each 2 weeks during the next 15, 2-week periods. The final level of feeding was 5 lb/head daily.
4	Gradually increasing	Corn silage fed at 9 lb/head daily for the first 2 weeks and increased 0.75 lb/head daily every 2 weeks during the next 16, 2-week periods. The final level of feeding was 21 lb/head daily.

One pen of 7 head was fed each treatment in trial 1 and two pens of 7 head were fed each treatment in trial 2. In both trials the amount of corn silage was programmed to average 15 lb/head daily for a feeding period of 238 days. Thus, it was designed that each steer would consume 3570 lb of corn silage during the feeding period. During the early part of trial 2 cattle fed in the two-phase and gradually decreasing programs were unable to consume their assigned amount of corn silage. Thus, corn silage consumptions for cattle in these programs were slightly less than designed. Dry matter contents of the corn silage were 40.6% (trial 1) and 46.9% (trial 2). Feedlot data were adjusted to a dressing percentage of 61.43% to remove differences due to fill. Carcass traits were not adjusted to equal carcass weights since the program was to sell the cattle after 238 days of feeding regardless of weight.

Feedlot performance and carcass characteristics are presented in tables 4 and 5. Cattle fed corn silage in the constant amount, two-phase and gradually decreasing programs gained faster than those in the gradually increasing program. Cattle in the two-phase program were most efficient (688 lb of dry matter per 100 lb gain) in converting feed to gain, followed closely by those in the gradually decreasing program (710 lb dry matter/100 lb gain). Cattle in the constant amount program required 738 lb of dry matter/100 lb of gain and those in the gradually increasing program required 773 lb of dry matter/100 lb of gain.

Cattle fed the greatest amount of corn grain early in the feeding program (gradually increasing) had the highest marbling scores and carcass grades. These data also suggest that rations influence carcass characteristics. Cattle in the gradually increasing program had the highest marbling scores and carcass grades despite the fact that they had the lightest carcass weights.

These data suggest that cattle fed corn silage in a two-phase program will be more efficient and return more profit than cattle fed corn silage in other systems. Newland _et al_. (1972) also reported that cattle fed corn silage to 750 lb, followed by shelled corn to finishing, were more efficient (657 vs 764 lb of feed/100 lb of gain) than cattle fed corn silage plus 1% concentrates for the entire feeding period. Fox and Black (1975) have suggested three reasons why cattle fed in the two-phase program are more efficient than those fed corn silage in other systems. First, the efficiency by which the energy in the silage and grain portions of the ration is influenced by the composition of the ration. Vance _et al_. (1972) stated, "The NE_g content of corn grain decreased while that of corn silage increased as the increment of corn grain in the ration declined. The greatest change was found, however, when 61 to 83% corn grain (dry matter basis) was fed, indicating that average NE_g values may be appropriate when less than 60% corn grain dry matter is fed with corn silage and supplement. These data suggest that the NEm value of a feed remains constant with varying proportions in the ration; however the NE_g value will vary depending upon the proportion of the feed in the total ration". Byers _et al_. (1975) reported that energy values at maintenance as well as at _ad libitum_ feed intakes were influenced by corn silage:corn grain ratio.

Another reason for the improved efficiency of cattle fed in the two-phase program is the compensatory performance that results when cattle are changed from a high forage to a high grain diet. This results in more efficient use of dietary energy during the high grain phase (Fox et al., 1972).

The third explanation for the efficiency of cattle fed in the two-phase program is that average weights during the feeding period are lower when the cattle are fed for relatively slow rates of gain during the early part of the feeding period. Thus, they spend fewer days on feed when their body weights are heavy and their maintenance requirements are high. Therefore, a lower percentage of the feed consumed is required to meet maintenance requirements and more is available for gain and feed efficiencies are improved.

It therefore appears that cattle will utilize their corn silage and corn grain most efficiently if they are fed high silage rations followed by a high grain ration. The length of the high corn silage feeding period can be varied to allow for changes in the amount of corn silage that is to be fed.

Drought-Damaged Corn Silage

Because of the dry weather which has occurred in many areas of the Midwest, many acres of corn have been harvested as corn silage because of the low potential yield of grain. Naturally, producers are concerned about the nutritive value of this drought-damaged corn silage and they have asked many questions about proper supplementation of rations which contain drought-damaged corn silage.

Drought-damaged corn silage is likely to be higher in crude protein than normal corn silage. Thus, producers should have their corn silage analyzed for protein content and should feed only the amount of protein supplement which is needed to meet animal requirements. Even though less than normal amounts of protein supplement may be needed when drought-damaged corn silage is fed, data from the University of Nebraska (table 7) suggest that better performance will result if the protein supplement contains plant proteins rather than urea. Their data shows that supplementation of normal corn silage with urea greatly improved rates of gain (1.03 vs. 1.64) and amount of feed/lb of gain (11.9 vs. 8.3). Soybean meal resulted in slightly faster gains (1.81 lb/day) and improved feed efficiencies (7.7 lb DM/lb gain). When drought-damaged corn silage was fed, supplementation with urea resulted in little improvement in daily gain (1.08 lb/day for cattle fed no supplement vs. 1.18 lb/day for cattle fed urea) and only a slight reduction in the amount of feed required per pound of gain (12.4 lb for cattle fed no supplement and 11.9 lb for those fed urea). However, supplementation with soybean meal resulted in improved gains (1.47 lb/day) and efficiencies (9.8 lb/lb gain).

Krause et al. (1976) noted that utilization of the protein in corn silage may depend on the form in which it exists in the corn plant. The protein in the stalk and leaves may be more soluble than the protein in corn grain. Thus, being more soluble, it would be more completely degraded to ammonia in the rumen than protein from corn grain. Because of the large percentage of protein in drought-damaged corn which is in the stalk and leaves and because of the large amount of ammonia produced in the rumen from this protein, the feeding of supplements which contain large amounts of urea may result in poorer performance than the feeding of soybean meal.

Drought-damaged corn silage may contain greater than normal amounts of nitrates. Thus, toxic silo gases are often observed at silo filling time when drought silage is harvested (the toxic nitrogen oxide gases are produced from nitrates). Since nitrate levels may be high, producers should have a nitrate analysis conducted on their drought corn silage.

Shown in tables 6 and 7 are the results of three comparisons of normal and drought corn silages. Tolman and Woods (1971) summarized the data in table 6 by stating, "Performance of the cattle was comparable between silage sources. It appears that effective use can be made of drought-damaged corn silage. The large reduction in value appears to be in reduced tonnage per acre and increased harvesting cost per ton instead of reduced feeding value per unit of dry matter. The extensiveness of drought damage will probably modify the relationship to "good" corn silage".

The data in table 7 show a lower feeding value for drought corn silage than the data in table 6. Comparison of the performances of cattle fed the two corn silages supplemented with soybean meal shows that those fed drought corn silage gained 19% slower and required 27% more dry matter per pound of gain than those fed normal (irrigated) corn silage. This drought corn silage was harvested after about 60 days without rain and it contained about 10 bu of grain per acre. Thus, it appears that the value of drought corn silage may depend on the length and severity of the dry period. However, harvesting drought-damaged acres as silage results in partial salvage of the crop. Drought-stressed corn silage will likely have 75 to 95% of the value of normal corn silage. Even though it has a lower energy value than normal silage, drought-stressed corn silage can be used effectively in rations for growing and finishing cattle.

Corn Plant Maturity

In the northern part of the corn belt a killing frost often occurs before corn plants are fully mature. When such a frost occurs, questions arise as to the nutritive value of the silage which results from the frost-killed corn plants. If frost-killed corn plants are harvested for silage before the leaves are lost, the silage should be similar to that from non-frosted corn harvested at the same stage of maturity (a factor which may lower the value of frosted corn plants is the likelihood of high levels of nitrates). Thus, presented in this section are the results of a study which was conducted at Ohio State University (Johnson and McClure, 1968) to determine the value of corn silage which was produced by corn plants at various stages of maturity.

Maximum yields of corn silage dry matter were obtained from corn at the dent to glaze stages of kernel maturity. Maximum dry matter digestibilities were observed when the corn plants were harvested at milk-early dough to dough-dent stages of maturity (table 8). However, the decline in dry matter digestibility was not large (71.9% for dough-dent, 68.1% for glaze, 68.8% for flint and 69.0% for post-frost). Crude protein digestibility was maximum at the milk-early dough stage of maturity (77.5%) and declined as maturity advanced. Voluntary intake of dry matter increased from the blister to glaze stages of maturity, then declined at the flint and post-frost stages of maturity. The low dry matter contents of the immature silages no doubt contributed to the low intakes of these silages. Maximum dry matter intake occurred at the glaze stage when the silages contained 33.5 to 33.9% dry matter. This is probably near the optimum dry matter content of corn silage. Since maximum dry matter yields were obtained at dent to glaze stages of maturity and since maximum dry matter digestibility and intake were at or near these stages of maturity, it appears that corn silage should normally be harvested at these stages of maturity. The corn plants contained 27.5 to 33.9% dry matter at these stages (table 8).

In summary, when a killing frost stops the growth of corn plants at an immature stage of kernel development dry matter yields are reduced and dry matter intakes of the high moisture (low dry matter content) corn silages will be lower than normal. However, dry matter and crude protein digestibilities may be higher than the digestibilities for more mature corn silage. Thus, frosted corn should be allowed to field dry to 65 to 70% moisture (30 to 35% dry matter) before it is harvested for silage. This should improve dry matter intakes and the greatest effect of the frost would be to reduce dry matter yields.

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Table 1. Performance of Steer Calves Fed Various Levels of Corn Silage: A Summary of 17 University Experiments.

Item	Percent corn silage dry matter in the ration dry matter							
	10	20	30	40	50	60	70	80
Avg. daily gain, lb	2.52	2.49	2.43	2.36	2.28	2.17	2.05	1.91
Avg. daily feed, lb of dry matter								
Corn grain	12.9	11.7	10.3	8.8	7.2	5.5	3.8	2.1
Corn silage	1.5	3.1	4.8	6.4	8.1	9.6	10.9	12.1
Supplement	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
TOTAL	15.3	15.7	16.0	16.1	16.2	16.0	15.6	15.1
Daily silage intake at 32% DM, lb	4.7	9.7	15.0	20.0	25.3	30.0	34.1	37.8
Feed/100 lb gain, lb of dry matter								
Corn grain	512	470	424	373	316	253	185	110
Corn silage	61	126	197	274	355	442	533	631
Supplement	33	36	37	37	39	41	44	47
TOTAL	606	632	658	684	710	736	762	788
Feed/600 lb of gain, lb of dry matter								
Corn grain	3072	2820	2544	2238	1896	1518	1110	660
Corn silage	366	756	1182	1644	2130	2652	3198	3786
Supplement	198	216	222	222	234	246	264	282
TOTAL	3636	3792	3948	4104	4260	4416	4572	4728
Days for 600 lb gain	238	241	247	254	263	276	293	314
Nonfeed costs/head for 600 lb of gain, $								
One lot/year[a]	48.01	48.30	48.86	49.53	50.38	51.62	53.24	55.23
Continuous feeding[b]	42.89	43.29	44.10	45.04	46.24	47.98	50.26	53.08

[a] Average nonfeed costs for farmers that feed one lot of cattle per year calculated to be $25.40 plus $0.095 per day.

[b] Average nonfeed costs for farmers that keep their lots full at all times calculated to be $11.00 plus $0.134 per day.

Table 2. Cost and Value of Corn Silage.

Cost of corn grain, $/bu.	Cost of corn silage, $/ton	Value of corn silage, $/ton
1.00	9.70	6.56
1.50	13.05	11.30
2.00	16.40	16.04
2.50	19.75	20.78
3.00	23.10	25.52
3.50	26.45	30.26
4.00	29.80	35.00

Table 3. Influence of Silage Level on Marketing Date.

Corn silage level, % of ration dry matter	Marketing date[a]
10	July 14
20	July 16
30	July 23
40	July 30
50	August 8
60	August 24
70	September 7
80	September 28

Table 4. Two Year Summary of Performance Data of Finishing Steers Fed Rations Containing Corn Silage in Four Different Feeding Proframs.[f]

	Silage feeding program			
Item Treatment No.	Constant amount 1	Two-phase 2	Gradually decreasing 3	Gradually increasing 4
No. steers	20	21	20	21
Avg initial wt, lb[a]	469	465	471	469
Avg final wt, lb[b]	1047	1045	1042	1013
Avg daily gain, lb[c]	2.43	2.44	2.40	2.29
Avg daily feed, lb[d]				
Corn silage	14.94(6.68)[g]	14.60(6.53)	14.64(6.55)	15.00(6.72)
Shelled corn	11.66(10.35)	10.54(9.35)	10.76(9.54)	11.37(10.07)
Supplement	1.00(0.90)	1.00(0.90)	1.00(0.90)	1.00(0.90)
TOTAL	27.60(17.93)	26.14(16.78)	26.40(16.99)	27.37(17.69)
Feed/100 lb gain, lb[e]				
Corn silage	615 (275)	598 (268)	610 (274)	655 (293)
Shelled corn	480 (426)	432 (383)	448 (398)	497 (440)
Supplement	41 (37)	41 (37)	42 (38)	44 (40)
TOTAL	1136 (738)	1071 (688)	1100 (710)	1196 (773)

[a]Shrunk weight.
[b]Calculated from hot carcass weights and a dressing percentage of 61.43.
[c]Significant differences: cattle in treatments 1, 2 and 3 gained faster than those in treatment 4 ($P<.05$).
[d]Significant differences: cattle in treatment 1 consumed more feed than those in treatments 2 or 3 ($P<.01$); cattle in treatment 4 consumed more feed than those in treatment 2 ($P<.01$) or those in treatment 3 ($P<.05$).
[e]Cattle in treatment 4 required more feed/100 lb gain than those in treatment 2 ($P<.01$) or those in treatment 3 ($P<.05$); cattle in treatment 1 required more feed/100 lb gain than those in treatment 2 ($P<.05$).
[f]Dexheimer et al. (1971).
[g]Values in parenthesis are dry matter.

Table 5. Two Year Summary of Carcass Data of Finishing Steers Fed Rations Containing Corn Silage in Four Different Feeding Programs.[g]

	Silage feeding program			
Item Treatment No.	Constant amount 1	Two-phase 2	Gradually decreasing 3	Gradually increasing 4
Carcass wt, lb	643	642	640	623
Fat depth, in	0.66	0.63	0.71	0.63
Rib eye area, sq in	11.3	11.3	11.5	11.2
KHP, %[a]	3.10	3.10	3.09	3.04
Marbling score[b,c]	5.56	5.73	5.36	6.25
Conformation score[d]	13.4	13.8	13.7	13.3
Carcass grade[d,e]	12.3	12.4	11.8	13.0
Cutability[f]	48.4	48.6	48.4	48.7

[a]Kidney, heart and pelvic fat expressed as a percent of carcass weight.
[b]Marbling score: 5, small; 6, modest; 7, moderate.
[c]Significant differences: cattle in treatment 4 had a higher marbling score than cattle in treatment 3 ($P<.01$) or treatment 1 ($P<.05$).
[d]Conformation scores and carcass grades: 10, average good; 11, high good; 12, low choice; 13, average choice.
[e]Significant differences: cattle in treatment 4 graded higher than cattle in treatment 3 ($P<.01$).
[f]Calculated by the equation: percent of boneless retail cuts from trimmed chuck, rib, loin and round = 51.34 - (0.0093) (carcass wt, lb) - (0.462) (%KHP) - (5.78) (fat depth, in) + (0.74) (rib eye area, sq in).
[g]Dexheimer _et al_. (1971).

Table 6. Comparison of Drought-Damaged and Normal Corn Silages.[a]

	Drought silage		Normal silage	
Item	No corn	6 lb corn/head daily	No corn	6 lb corn/head daily
No. of steers				
1968-69[b]	24	24	24	24
1969[c]	20	20	20	20
TOTAL	44	44	44	44
Daily gain, lb				
1968-69[b]	1.52	1.70	1.46	1.87
1969[c]	2.24	3.01	2.65	2.80
Average	1.88	2.36	2.06	2.34
Feed/lb gain, lb of dry matter				
1968-69[b]	10.3	10.1	11.2	10.0
1969[c]	7.8	6.3	7.0	6.6
Average	9.0	8.2	9.1	8.3

[a]Tolman and Woods (1971).
[b]Calves fed 91 days.
[c]Light yearlings fed 63 days.

Table 7. Comparison of Drought-Damaged and Normal Corn Silages.[a]

	Drought silage			Normal silage		
Item	No protein	Urea	Soybean meal	No protein	Urea	Soybean meal
No. of steers[b]	28	28	28	9	9	9
Initial wt., lb	420	424	425	412	399	400
Daily gain, lb	1.08	1.18	1.47	1.03	1.64	1.81
Feed intake, lb of DM	13.2	14.0	14.4	12.3	13.6	13.9
Feed/lb gain, lb of DM	12.4	11.9	9.8	11.9	8.3	7.7

[a]Krause _et al_. (1976).
[b]Calves fed 190 days.

Table 8. Influence of Stage of Maturity of Corn Silage on Composition, Digestibility and Intake.[a]

Stage of maturity	Dry matter, %		Crude protein, %[b]		Dry matter digestibility, %		Crude protein digestibility, %		Voluntary intake, g DM/W$^{.75}$	
	1964	1965	1964	1965	1964	1965	1964	1965	1964	1965
Blister	20.9	21.3	12.0	11.4	65.3	71.0	74.7	76.7	42.9	51.0
Early milk	19.9	22.1	12.1	11.9	66.7	67.9	75.9	75.6	42.6	49.4
Milk-early dough	21.9	24.9	10.8	12.3	69.5	72.6	77.6	77.4	54.1	52.7
Dough-dent	27.5	27.9	10.4	11.4	71.9	71.9	76.3	75.6	55.6	59.3
Glaze	33.5	33.9	9.4	11.0	67.8	68.4	69.1	68.0	58.9	61.9
Flint	45.4	38.4	9.0	11.0	71.0	66.6	66.9	67.2	54.1	58.8
Post-frost	49.5[c]	46.7	8.7	10.5	69.8	68.2	64.8	66.3	54.0	52.4
Mature	----	71.7	----	10.9	----	68.6	----	59.4	----	52.7

[a]Johnson and McClure (1968).
[b]Dry matter basis.
[c]Water added at ensiling time.

UTILIZATION OF CROP RESIDUES AND HIGHLY LIGNIFIED WASTE PRODUCTS IN WINTERING RATIONS FOR BEEF COWS

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Although residues and waste fiber can be fed in many types of ruminant rations at low levels as a replacement for the forage, greater usage can probably be found in maintenance or wintering rations. A crop residue or waste material is no better than its available nutrient composition. How closely this nutrient composition will meet the requirement of animals determines how the material can be used and what supplemental feeds are required. The nutrient requirement of 1,100 lb. dry pregnant mature cows in the middle third of pregnancy could be used as a basis for requirements for a maintenance or wintering ration for breeding stock. The requirements for such animals (N.R.C., 1976) are as follows:

Nutrient Concentration in Diet Dry Matter

Minimum dry matter consumption (lb)	Total protein (%)	Digestible protein (%)	NE_m (Mcal/lb)	ME (Mcal/lb)	TDN (%)	Ca (%)	P (%)
15.9	5.9	2.8	0.49	0.86	52	0.18	0.18

Daily Nutrients Per Animal

Minimum dry matter consumption (kg)	Total protein (kg)	Digestible protein (kg)	NE_m (Mcal)	ME (Mcal)	TDN (kg)	Ca (g)	P (g)	Vitamin A (thousands IU)
7.2	0.42	0.20	8.14	14.1	3.9	13	13	20

My allotted time for this presentation will not permit complete coverage of the utilization of all residues and wastes. Only the utilization of residues or fibrous wastes considered important and available in quantity in South Dakota are briefly reviewed from selected feeding experiments in various areas.

Straws and Other Fibrous Cereal Grain Residues

Straw and chaff can be considered to be another cash crop in addition to the grain if used as a feed. G. W. Mathison, University of Alberta, states that the weight of straw produced on a given land area is greater than weight of grain produced and accounts for about 50% of the gross energy, 30% of the digestible energy as well as 20% of the crude protein produced on an acre of land. The nutrient content of various straws is quite uniform but does vary somewhat from year to year and perhaps its composition is affected by the area in which the grain is produced. Average compositions of common straws might be as follows:

Nutrient Content of Straw (Dry Basis), Percent

Straw	Crude protein	TDN	Crude fiber	Ca	P
Wheat	4.4	40.6	37.0	0.19	0.08
Barley	4.9	42.2	37.7	0.30	0.09
Oats	4.4	44.8	36.3	0.24	0.10
Mixed	5.1	--	--	0.21	0.10

Consumption - 1.5 to 2.0 lb. per 100 lb. body weight

It is apparent that straws will be too low in protein and phosphorus to meet the minimum requirement for wintering mature animals. With the realization of the deficiencies in straw of protein, energy, vitamin A, phosphorus and perhaps other minerals as well, how can straw be used in wintering rations and what would be the expected animal response?

Wintering on Straw Alone

It has been shown that cows can be wintered on straw and chaff plus supplemental salt if animals are in sufficient condition to withstand the weight losses. During one 3-year experiment in which the wintering period varied from 132 to 160 days, animals experienced an average loss in these experiments of 126 lb. per animal. The weaning weights of the calves were not greatly different from animals receiving supplemental feeds. It was suggested that wintering on straw alone does preclude that winters should be mild and animals must be in good fall condition. These experiments were performed in Montana by Arnett and McChord in the late 1920's. Wintering animals on straw alone was not too uncommon during this period.

Animals can be expected to lose weight on straw alone because the intake of 1.5 to 2.0 lb. of straw per 100 lb. of body weight does not meet the minimum energy or protein requirements.

Wintering on Supplemented Straw Rations

Supplementation with protein appears to be the most critical to increase straw intake and to increase fiber digestibility. Reports of increased intake from 14 to 25% by protein supplementation of straw have been made by various researchers. It appears that proper level of protein supplementation is more important in straw supplementation than the source of protein. Nonprotein sources were less valuable than plant protein sources in some instances. In general, it was shown that 10 lb. of hay or 1 lb. of cottonseed meal daily would substantially reduce weight losses experienced when straw alone was fed. Slow release nonprotein products appear to have merit as protein supplements with straw.

Energy addition to rations high in straw is not as clear-cut as protein supplementation and may decrease fiber utilization somewhat, depending on the level of grain added. The intake of straw does not vary greatly when additional energy is provided and energy additions should be based on condition of the animals being wintered.

Since some questions may be asked as to the value of chaff as compared to straw, mention of a comparison made by Morrison and Canadian workers might be in order. Although actual feeding data are lacking, nutrient analysis suggests that chaff has a higher protein and phosphorus level but less energy unless the grain that may be included is considered. The grain content can be from 1 to 3%, depending on harvesting machines used.

The Maryland Experiment Station suggests from their experience with straw feeding that small grain straw with adequate supplemental protein could replace up to two-thirds of the hay fed to wintering pregnant beef cows. A comparison was also made between all hay (brome and wheatgrass) wintering ration and a ration composed of 50% hay and 50% straw with no protein supplementation in either ration type. The young cows fed hay and straw lost the most weight. The straw feeding did not appear to affect the calf birth weight or livability. All animals were supplemented 1 month before calving with hay and grain and straw feeding was discontinued. Using straw to replace part of the hay in these experiments reduced costs about $1.00 in 1972, $2.25 in 1973 and $4.67 per cow month in 1975 as feed costs began to rise during this period. Even though animals may lose more weight due to winter straw feeding, the effect on birth weight and animal health was not noted in any of these experiments.

The North Dakota Experiment Station performed straw feeding experiments during the late 1960's in which a wintering ration of 20 lb. of crested-brome hay per day was compared to a ration of 7 lb. of hay, 13 lb. of wheat straw and 1 lb. of soybean oil meal daily. Animals on rations containing straw lost on the average during a 3-year experiment about 39 lb. more weight during wintering than animals fed hay. Birth weight and growth rate of the calves were not affected by the level of winter nutrition of their dams--remembering that animals did receive additional feed prior to calving. No differences were noted in the conception dates due to the two levels of nutrition. The cost of a wintering program at that time was about the same between feeding programs. Comparative costs depend on the value assigned to the straw and the cost of hay. It was concluded at this station also that two-thirds of the hay in a beef cow wintering ration can be replaced by straw plus supplemental protein without adversely affecting the cow's ability to wean a healthy calf, provided she is in good condition upon entering the winter period. It may or may not reduce the winter feed bill, but it does extend a short hay supply.

Experience with straw feeding in North Dakota suggests that animals should be watched more closely than usual. Straw feeding can cause constipation and impaction of the abomasum (true stomach) which in turn causes permanent nerve damage with animal losses. It may not be readily apparent that animals are losing condition either, since if intake of straw is high, the animals may be disintended and mistaken as being in good condition.

<u>Conclusions for Straw Feeding</u> (Canadian and North Dakota Experiment Stations)

1. Cereal grain by-products represent a large source of potential nutrients for wintering feed.

2. It utilizes a feed raised on the farm or ranch that might otherwise be wasted.

3. Cattle can be wintered on straw alone in an emergency if winter conditions are ideal and animals are in good condition before this time. Excessive weight losses can occur.

4. Cows will consume from 1.5 to 2.0 lb. of straw per 100 lb. of body weight and increasing this intake with well-balanced diets is difficult.

5. Protein supplementation is most critical to maximum intake and digestibility of wintering straw diets, with plant proteins being the most valuable.

6. The effectiveness of grain supplementing straw diets is open to question if used to increase intake and digestibility of the straw portion of the diet.

7. The overhead of winter feeding can be minimized when there is a hay shortage.

8. Feeding straw will release some hay for cash sale.

9. It appears that an attempt should be made to collect all grain by-products from grain harvest to improve the total value of straw.

10. Some care must be taken in straw-based rations since constipation and abomasal impactions can occur. Providing adequate salt, minerals, water and also perhaps protein supplements can assist in alleviating impactions.

Corn Stalks, Cobs and Miscellaneous Corn Residues

Of all the corn residues possible, corn stalks are the most versatile as a wintering feed since it can be left in the field after the corn harvest to be grazed in the fall and winter, ensiled or harvested as stalks in various ways. Its composition will be determined by the amount and type of other corn plant parts which accompany the stalk itself. Thus, one should consider composition of corn plant parts to make estimates of nutrient value of corn residue material.

A study made at Iowa State University considered the composition of major parts of the corn plant as follows:

Composition and Digestibility of the Corn Plant

	Dry matter	Crude protein	*In vitro* digestible dry matter	Ash
Grain	73	10.2	91	1.6
Leaf	76	7.0	58	13.7
Husk	55	2.8	68	3.4
Cob	58	2.8	60	1.4
Stalk	31	3.7	51	4.7
Husklage (Foster)	78	3.7	65	3.3
Stalkage (Hesston)	66	4.2	56	10.6
Stalkage (Flail)	55	3.8	51	--

A comparative study of the value of corn residues by the University of Nebraska provides a good rule of thumb for the nutritive value of corn plant residues. In essence, the study states that the digestibility of corn residues arranged in descending order would be the grain followed by husk, leaf, stalk and cob. The protein content arranged in the same fashion would be grain, husk, stalk and cob. Weather effect over time tends to decrease the value of corn residues left in the field as the winter progresses. The value of corn stalks left in the field without harvesting or grazing has been estimated by a Nebraska agricultural economist in terms of its fertilizer value in subsequent years. The stover from a 100-bushel corn crop was estimated to contain approximately 56 lb. nitrogen, 3 lb. phosphorus, 27 lb. potassium and 17 lb. calcium. This might be valued at about $1.20 per acre plus the value of organic matter that stalks will generate.

Wintering Use of Stalks or Residues Grazed in the Field

Allowing animals to graze the corn fields following the corn harvest is a common practice and has been estimated to be the cheapest method of utilization of corn residues for wintering cattle or other ruminants. This method does have its limitations, however, and must be a factor to consider when planning winter feeding. Only 30 to 35% of stover is actually utilized by grazing animals. Nutrient value decreases with the length of the grazing period since animals will select the more digestible portions first, leaving indigestible portions as the potential for selection diminishes. Snow may cover the more digestible and nutritive portions of the corn residues such as the residual grain and husks. Wind may also blow husks and leaves out of the field. As stated previously, weather may cause a decrease in digestibility of corn residues as the winter progresses. This will mean that the value of grazing residue is decreasing while the demand for energy of the animal may be increasing due to weather deterioration. Heavy snow and severe weather may cause grazing of corn residues in the field to cease altogether without warning.

It is difficult to really estimate how long a cow can be maintained when grazing under ideal conditions, but it is estimated that 1 ton of stover is available for every 30 to 35 bushels of corn harvested and, of course, not all the stover will be grazed. If a cow eats 30 lb. per day, she will have consumed at least an acre of available stover in 2 months.

Wintering Animals on Harvested Corn Residues

Harvesting corn residues, although more costly than grazing, provides more total roughage from a given field and does overcome some of the disadvantages of grazing. Harvested residues other than silage can be moved from one location to another as needed, especially since the residues can be made into stacks with various types of collecting and stacking machines developed in recent years. In general, the method of harvesting will be an individual decision as to which method is the most convenient and the least costly.

Corn Stalks

Corn stalks can now be easily chopped and stacked to be fed either in the field or in a feedlot. Stalks can be further processed from stacks or directly into silage similar to traditional silage made from the entire plant. Additional water is usually required because of maturity of the stalk. Stalk roughage source. Since my consideration is only wintering rations, it will not be discussed. Wood materials with lower levels of lignin encrustation such as aspen wood have potential in wintering rations if properly supplemented. The most serious deficiencies would be protein, phosphorus and vitamin A. Aspen tree material has approximately 1% crude protein. Its acceptability as a feed by wild ruminants is well known but difficult to evaluate. Some experimentation is now in progress on wood wastes at South Dakota State University using the material in growing and finishing rations. Please refer to the field day bulletin for the progress summary of this work.

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Rumensin for Growing and Finishing Cattle[1]

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Introduction

Much of the research with feedlot cattle has been devoted to studies of ways to improve feed utilization. A large portion of feed energy, and also protein, available to the ruminant results from microbial fermentation in the rumen, or rumen-reticulum. Environmental conditions maintained in the rumen are important in the rate of fermentation and the resulting end-products. Numerous experiments have shown that volatile fatty acids (VFA)--major ones being acetic, propionic and butyric--produced by microbial fermentation in the rumen play major roles in energy metabolism of ruminants.

The nature of the diet may influence number and type of rumen microorganisms resulting in changes in their activity. Nature of the diet then would be expected to result in changes in amounts and/or ratios of the VFA, ammonia and other products of fermentation and in synthesis of various nutrients. Such changes have been shown to result from altered physical properties of the diet, quantities and ratios of dietary nutrients and a number of non-nutritive feed additives some of which are antibacterial in nature.

Concentrations and relative proportions of these major individual acids are known to influence the value of the ration for fattening. As compared to acetic, propionic and butyric acids produce less heat. Dietary conditions resulting in an increase in propionic acid are those generally associated with higher rates of gain and improvement in feed utilization.

Considerable research has been devoted to study ways of increasing the relative proportion of propionic acid during fermentation in the rumen. It has been shown that the proportion of VFA as propionic acid may be increased by a number of factors including pelleting of feeds, increase in the concentrate portion of the diet, processing methods which involve heat treatment and reduction in particle size and additions of certain non-nutritive products. The ultimate objective is to obtain beneficial effects on feed utilization which exceed costs involved.

Recent research has shown that monensin in the form of the sodium salt (Rumensin) is a product which improves feed utilization by ruminants. The product is cleared for feeding in rations for growing and finishing cattle. There has been considerable interest in research with the product and it appears to have been put to wide use in the cattle feeding industry.

Results of some of the research reported are reviewed here to show the mode of action and results obtained under various conditions of use.

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[1]Presented at Twentieth Annual Beef Cattle Feeders Day, November 3, 1976.

Rumen Fermentation

Products or dietary conditions which bring about important changes in total volatile fatty acid (VFA) production during rumen fermentation or changes in the proportions of the major ones--acetic, propionic and butyric--are of particular interest in feeding of ruminants. An increase in the rate and/or amount of fermentation means more of the nutrients consumed are potentially available to the animal. Changes in the proportions of VFA result in changes in the form of energy available to the animal with propionic acid being more favorable for growth and fattening.

Monensin in the form of the sodium salt (Rumensin) has been shown to result in marked increases in propionic acid production. Levels of acetic and butyric acid decrease with total VFA levels essentially unaffected. The response in propionic acid production has been greater with high roughage rations than with high grain rations.

High grain rations which are associated with high rate of production and low feed requirements results in a higher proportion of propionic acid in relation to other VFA than do high roughage rations. This is illustrated in table 1 showing typical values with high concentrate and high roughage rations (Raun, 1975).

Table 1. Typical Rumen VFA Percentages as Affected by Type of Ration

Ration	Molar %		
	Acetic	Propionic	Butyric
High roughage	69	20	11
High concentrate	58	35	7

The effects of Rumensin on fermentation in the rumen has been studied in the laboratory and with cattle under various conditions as to rations and level of Rumensin. Data on rumen fermentation has been obtained in many of the feeding experiments. Results have been very consistent in showing an increase in the amount of propionic acid, decreases in acetic and butyric but with essentially no change in total VFA production from feeding Rumensin. This is illustrated in table 2 showing results of growing-finishing trials summarized by Grueter et al. (1976).

Data presented in table 2 represent results from six experiments conducted at various locations where the cattle were fed in a growing trial followed by a finishing trial. The levels of VFA for the control cattle represent rather typical values for high roughage and high concentrate rations as illustrated in table 1.

There was a marked increase in propionic acid production with increasing level of Rumensin in the growing period. Levels of acetic and butyric decreased with only small changes in total acids (total acids not shown in the table). Amount of propionic acid was at the highest level with 40 g/ton of Rumensin. The amount was 52.6% more than for control cattle.

Table 2. Effect of Rumensin on Ruminal VFA

Rumensin (g/ton feed)	VFA, % of Total Acids					
	Growing Period			Finishing Period		
	Acetic	Propionic	Butyric	Acetic	Propionic	Butyric
0	69.1	20.9	10.0	55.2	35.4	9.3
10	67.4	23.8	8.8	54.1	38.0	7.9
20	63.8	27.5	8.7	54.3	37.5	8.2
30	61.9	30.0	8.2	52.1	40.0	8.0
40	60.6	31.9	7.5	53.0	40.1	6.9

Control cattle in the finishing trials (table 2) had a higher level of propionic acid with lower levels of acetic and butyric than those in the growing trials. While changes were in the same direction with Rumensin as in the growing trials, the changes were of smaller magnitude. However, at each level of Rumensin, there was a larger amount of propionic acid with finishing rations.

Results of these six experiments indicate that propionic acid production reached about maximum with Rumensin at 30 g/ton of feed with either growing or finishing rations. Several other experiments have shown similar responses to Rumensin regarding level of the product and type of rations.

Feedlot Experiments

Research with Rumensin fed to growing and finishing cattle has been very active during the past 2 to 3 years. Results of numerous experiments have been reported. A review of all published reports is not intended here.

In view of the apparent greater effects of Rumensin on propionic acid production with growing-type rations in comparison to finishing-type rations, feedlot response might be expected to vary with type of ration and level of the product. There has been considerable variation in the reported research as to type of rations, size of cattle, length of feeding and levels of Rumensin. Feedlot performance for the six experiments summarized by Grueter *et al.* (1976) are presented as being representative of expected performance. Both growing periods and finishing periods are shown in this summary.

Growing Rations

Results for the six experiments with growing rations conducted at different locations are summarized in table 3.

Feed intake decreased with increasing levels of Rumensin up to the highest level (40 g/ton) fed. This has been a consistent finding in most experiments reported and appears to be observed almost immediately upon first access by cattle to Rumensin.

Table 3. Growing Trials with Rumensin
(6 experiments)

Rumensin	Daily feed		Daily gain		Feed per lb. gain	
g/ton feed	lb.	% of control	lb.	% of control	lb.	% of control
0	21.35		2.25		9.44	
10	21.16	99.1	2.36	105	9.03	95.7
20	19.96	93.5	2.30	102	8.72	92.4
30	19.29	90.4	2.27	101	8.59	91.0
40	18.34	85.9	2.11	94	8.94	94.7

There was only a small effect of Rumensin on weight gain of the cattle in the six experiments. Weight gain was at least equal to the control group up to the 30 g/ton level. Those fed the 40 g/ton level gained at a slightly lower rate. The 40 g/ton level has not always resulted in reduced weight gain. However, levels in excess of this appear to be excessive as measured by feed intake and weight gain.

Similar weight gains with less feed intake resulted in improved feed efficiency. Lowest feed requirements were obtained at the 30 g/ton level. The improvement over controls at this level amounted to 9.0% which was similar to the reduction in feed intake (9.6%) from controls.

Results of these growing experiments indicate that the most effective level of Rumensin is 30 g/ton of air dry feed when measured by feed intake, weight gain and feed efficiency. Data on rumen fermentation would also support this level. While there has been some variation in response obtained, an improvement in feed efficiency of 10-12% appears typical with growing rations with only a small effect on weight gain. Therefore, feed intake would be reduced to about the same degree as the improvement in feed efficiency. Results appear to be similar for heifers as for steers and with various types of rations tested.

Finishing Rations

Results obtained with the cattle in the above growing experiments during a following finishing period are presented in table 4.

Effects of the various levels of Rumensin on feed intake in these finishing experiments were very similar to the effects in the growing experiments. The response in weight gain was also similar except there appeared to be no reduction in comparison to controls at the 40 g/ton level. Under these conditions, lowest feed requirements were obtained at the 40 g/ton level of Rumensin.

Differences between the 30 and 40 g/ton level of the product were small in terms of weight gain and feed efficiency. Therefore, there would appear to be little if any advantage for the 40 g/ton level over the 30 g/ton level which appeared to be the most efficient level in the growing experiments.

Table 4. Finishing Trials with Rumensin
(6 experiments)

Rumensin	Daily feed		Daily gain		Feed per lb. gain	
g/ton feed	lb.	% of control	lb.	% of control	lb.	% of control
0	20.66		2.12		10.06	
10	20.31	98.3	2.20	104	9.47	94.1
20	19.18	92.8	2.12	100	9.35	92.9
30	18.76	90.8	2.15	101	8.91	88.6
40	18.02	87.2	2.12	100	8.75	87.0

Results of the six experiments show similar benefits from Rumensin with finishing rations as with growing rations. High grain finishing rations produce more ruminal propionic acid and the concentration is less affected by Rumensin than are high roughage growing rations. However, depression in feed intake from the product appeared to be of similar magnitude with either type of ration. Because of the lower feed intake with high concentrate rations (table 3 and 4), a higher concentration of Rumensin per ton of air dry feed might be indicated for heavy cattle during late finishing periods.

Pasture Experiments

The effects of Rumensin on rumen fermentation and feed efficiency of feedlot cattle has raised questions as to possible effects when offered to cattle on pasture with pasture forage as the main feed. Potter *et al.* (1976) reported results of three pasture experiments and one experiment where cattle were fed green-chop forage for periods of 105 to 168 days. Supplements with varying levels of Rumensin were fed at 2 lb. daily to the cattle (wt. in various experiments from about 450 to 700 lb.). A summary of weight gains for the four experiments is shown in table 5.

Table 5. Weight Gain of Growing Cattle Fed Rumensin
on Pasture or with Green-Chop

	Rumensin, mg/day					
	0	50	100	200	300	400
Daily gain	1.19	1.21	1.32	1.39	1.32	1.28
Percent of control		102	111	117	111	108

The data in table 5 shows an improvement in weight gain from Rumensin. The 200 mg daily level appeared to be the optimum amount.

Cattle fed green-chop in the one experiment did not show the depression in the feed intake from Rumensin encountered in the feedlot trials with high roughage rations, except for a slight depression at the 300 and 400 mg daily levels. Feed requirements were improved most over controls at the 200 mg level (14.4%).

Propionic acid production in the rumen increased with increasing levels of Rumensin up to the highest level fed (400 mg daily). The response appeared to be similar to results obtained with feedlot cattle fed growing rations with similar daily amounts of Rumensin.

Effects of Rumensin on pasture forage intake were not attempted in the experiments. The small amount of supplement could not contribute greatly to the total energy intake. It was, therefore, concluded that Rumensin favorably altered rumen fermentation and thus resulted in more efficient use of the pasture forage consumed. This resulted in improvement in weight gain when fed Rumensin. The conclusion would be supported by results of the experiment with green-chop forage.

Improvement in pasture gains by cattle fed Rumensin in low levels of grain or protein supplement has also been reported by Anthony et al. (1975), Oliver (1976) and Brethour (1976) with improvements ranging from 7.7 to 38.2% over control cattle. The 17% improvement in weight gain for cattle fed 200 mg of Rumensin on pasture reported by Potter et al. (1976) would appear to be an expected average response on basis of limited research to date.

Carcass Characteristics and Abcessed Livers

Since Rumensin increases the amount of propionic acid in the rumen and thus changes the form of energy available to the animal, carcass composition could be affected. Carcass data were obtained in many of the finishing experiments reported.

Brown et al. (1974) compiled data on quality grade and calculated cutability from 1147 cattle fed various levels of Rumensin. The data are shown in table 6.

Table 6. Rumensin Effects on Carcass Grade and Cutability

Rumensin (g/ton feed)	Number cattle	Quality grade[a]	Calculated cutability
0	182	7.13	48.74
5	177	7.31	48.74
10	182	7.19	48.71
20	182	7.16	48.92
30	242	7.12	48.89
40	182	6.87	49.30

[a]6 = high Good, 7 = low Choice, 8 = avg. Choice.

The data in table 6 show little if any effect of Rumensin from 5 to 40 g/ton of feed on carcass quality grade or percent cutability. Other studies have shown no apparent consistent effect of Rumensin on percent of carcass fat, percent of lean and dressing percent at levels up to 40 g/ton of feed.

A high incidence of abcessed livers is frequently encountered when cattle are fed high grain finishing rations. Some antibiotics--chlortetracycline, oxytetracycline bacitracin and tylosin--have been shown to reduce the incidence when fed in rations proned to cause abcessed livers. Without one of the above antibiotics along with Rumensin (combination not cleared for use at present), the incidence of abcessed livers has been reported to be quite high in several experiments. The incidence appears to have been highly variable between experiments and between replicates within experiments. Rumensin does not appear to have an effect (cause or prevent) on incidence of abcessed livers at levels commonly tested.

Rumensin with Implant Treatments

Numerous experiments over the past several years have shown that implant treatments with diethylstilbestrol (DES), zeranol (RAL) and Synovex have resulted in improvements in weight gains of feedlot steers of 10-15% with 10-12% improvement in feed efficiency. Questions are raised as to the likely response from these implant treatments with Rumensin. Obviously, there are limits as to how many times weight gains and feed efficiency can be improved in an additive manner. Also, the higher the level of production the more difficult it becomes to obtain additional responses from various additives or implants. Unless products differ in mechanism of action, combinations may be merely a matter of dosage level.

Several experiments with finishing cattle have been reported where implant treatments were used with and without Rumensin. When more than one level of Rumensin was fed, the 30 g/ton of feed has been used for the most part for comparisons in this report. Results for some of the experiments are presented in table 7.

Table 7. Feedlot Cattle Response to Implants with Rumensin
(Percent Improvement from Implant)

Reference	Implant	Without Rumensin		With Rumensin	
		ADG	F/G	ADG	F/G
Perry *et al.*, 1975	36 mg DES	14.4	6.6	17.6	5.0
Hale *et al.*, 1975	Synovex-S			13.5	6.3
Davis *et al.*, 1975	30 mg DES	10.5	8.4	14.4	24.9
Weichenthal *et al.*, 1976	Synovex-S			15.4	12.7
	36 mg RAL			12.4	11.2
Nissen & Trenkle, 1976	30 mg DES	6.0	5.9	9.5	7.2
Sherrod *et al.*, 1976	36 mg DES	16.1	10.3	11.1	-3.6
	36 mg RAL	14.3	10.0	6.4	2.8
	Synovex-S	18.9	11.2	9.8	0

Where direct comparisons were made as to response to implant treatments with and without Rumensin, in general, the results indicate that the response to implants were similar with Rumensin as without the product. This would mean that the response to Rumensin and implant treatments could be expected to be additive. Burroughs et al. (1975) also concluded there was an additive response to Rumensin and implant treatments. The experiment by Sherrod et al. (1976) would appear to be an exception as to an additive effect, but they did obtain sizable improvements from implants with Rumensin.

Rumensin with Antibiotics

Rumensin has been referred to as an antibiotic but it appears to act quite differently from those commonly used as feed additives. Some experiments have tested Rumensin in combination with an antibiotic, mostly tylosin (the combination not cleared for use at present).

Ali et al. (1975) reported tylosin at 10 g/ton of feed without Rumensin resulted in 7.5% and 6.9% improvement in weight gain and feed efficiency, respectively, when fed with alfalfa haylage. With Rumensin at 30 g/ton of feed, improvements over no tylosin were 7.0 and 7.2%. Response was somewhat less when the roughage portion (20%) of the ration was cottonseed hulls with protein supplement of soybean meal. In this instance, improvements in weight gain and feed efficiency amounted to only 2.8 and 2.7% without Rumensin and 3.8 and 3.6% with 30 g/ton of Rumensin.

Matsushima and Haaland (1975) reported no effect of tylosin (10 g/ton feed) on feedlot performance of cattle with or without Rumensin. However, incidence of condemned livers were reduced from an average of 59.0% without tylosin to 5.8% with the antibiotic. Rumensin appeared to have no effect on liver condemnations. Sherrod and Burnett (1976) also reported no beneficial effect of tylosin on feedlot performance with or without Rumensin. They observed a reduction in abcessed livers from an average of 11.8% to 5.2% from tylosin at 90 mg per head daily.

Farlin (1976) also tested tylosin with and without Rumensin. He observed small improvements in weight gain and feed efficiency from tylosin at 10 g/ton of feed either with or without Rumensin. Incidence of liver condemnations were reduced by tylosin.

These few experiments with tylosin alone or in combination with Rumensin show small and variable effects of the antibiotic on feedlot performance. However, where data on liver condemnations were obtained, the antibiotic resulted in marked reductions in abcessed livers.

Levels and Sources of Protein with Rumensin

The effects of Rumensin on propionic acid levels in the rumen raises questions concerning a possible protein sparing effect of the product and on the efficiency of nonprotein nitrogen utilization. Some researchers have conducted experiments designed to help answer these questions.

Davis and Erhart (1976) fed 192 steers (avg. 764 lb. initially) for 120 days on rations composed of corn grain, corn silage and supplement (9.5% protein).

Urea was added to give rations with 11.5% protein, but with the urea withdrawn at 0, 42, 84 and 120 days during the experiment. Urea resulted in no improvement in weight gain or feed efficiency when rations were fed without Rumensin. When Rumensin was fed at 30 g/ton of feed, feeding urea resulted in slight improvements in weight gain but essentially no effect on feed efficiency. Cattle fed Rumensin but no supplemental protein as urea gained at a slightly slower rate but with an 8% improvement in feed efficiency over those fed no Rumensin. At other lengths of urea feeding, cattle fed Rumensin gained from 3.5 to 5.5% faster with 17.1 to 18.6% improvement in feed efficiency over those not fed Rumensin. The greater improvement in performance from protein supplementation as urea with Rumensin would indicate no reduction in protein needed with Rumensin but that urea utilization was apparently improved by Rumensin. Garrett (1976) concluded that urea as compared to cottonseed meal did not alter the influence of Rumensin.

This is an area under investigation at the present time. More results of research are needed to determine effects of Rumensin on protein needs and its effect on utilization of nonprotein nitrogen. Some research is now in progress. For the present, it would appear advisable to supplement feedlot cattle fed Rumensin with protein in about the same manner as for those not fed the feed additive.

Adaptation Periods for Rumensin

When cattle are first placed on feeds containing Rumensin, there may be a substantial initial reduction in feed intake. This effect will be influenced by size of cattle and level of Rumensin. It is of temporary nature, but feed intake will be about 10% less throughout the feeding period.

The optimum level of Rumensin in a complete feed appears to be 30 g/ton of air dry feed. Since feed intake is related to body weight, the amount of Rumensin consumed from the complete feed increases as the cattle gain in weight and consume more feed. Under this system of feeding, there is a gradual increase in intake of Rumensin with increasing intake of feed. However, it is suggested that the level of Rumensin in a complete feed should be at 10 or 20 g/ton during the first 2 or 3 weeks.

When Rumensin is offered in a supplement, suggested rates of supplementation are based on feed consumption as follows:

Feed Consumption	Daily Levels of Rumensin
Less than 14 lb.	150 mg/head
More than 14 lb.	200 mg/head
More than 20 lb.	Up to 300 mg/head

Over feeding of Rumensin to light calves during periods of stress could reduce feed intake during a critical time and add additional stress. Since the supplement fed at constant levels will make up a larger percentage of the total ration during early stages in the feedlot but decreasing as feeding progresses, it would be advisable to follow the suggested levels in a daily supplement. It is recommended that no cattle receive more than 360 mg of Rumensin daily. (A concentration of 30 g/ton of feed is equal to 15 mg/lb. of the feed.)

Some researchers have compared various levels of Rumensin during the period of adaptation. Perry et al. (1975) observed essentially no difference between Rumensin at 30 g/ton of feed initially and 10 g/ton for 10 days then 30 g/ton for the remaining days of a 133-day experiment with 600-lb. cattle. Rations were about 18 lb. of corn silage, 6 lb. of corn grain and 2 lb. of supplement. In another experiment, Perry et al. (1976) reported average feed intake by 4-week periods over a 232-day experiment. Rumensin at 30 g/ton of feed initially or 10 g/ton initially than 30 g/ton resulted in essentially the same average daily feed intake at each 4-week period throughout the experiment. However, feed intake was reduced in comparison to controls fed no Rumensin.

Sherrod (1976) fed cattle of (about 550 lb. initially) a high concentrate ration to final weights of about 1100 lb. Rumensin was fed at 30 g/ton of feed throughout the experiment, 10 g/ton for 7 days then the 30 g level and 10 g/ton for 21 days then 30 g/ton. Rumensin had no effect on weight gain but improved feed efficiency. However, there were essentially no differences between methods of Rumensin supplementation on feed intake over the entire experiment. Feed intake by periodic periods was not reported.

It is well established that Rumensin reduces feed intake. Levels as low as 10 g/ton of feed appear to cause this effect, especially during early periods of feeding. However, it would seem reasonable to expect the effect would become more evident with increasing levels of Rumensin. The importance of a temporary period of substantial reduction in feed intake will depend upon size of cattle, general health, weather conditions and nutritional adequacy of the rations. Therefore, suggested procedures during the period of adaptation should be followed. Deviations from suggested procedures should be made only when giving due consideration to factors listed which may affect early performance of the cattle.

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