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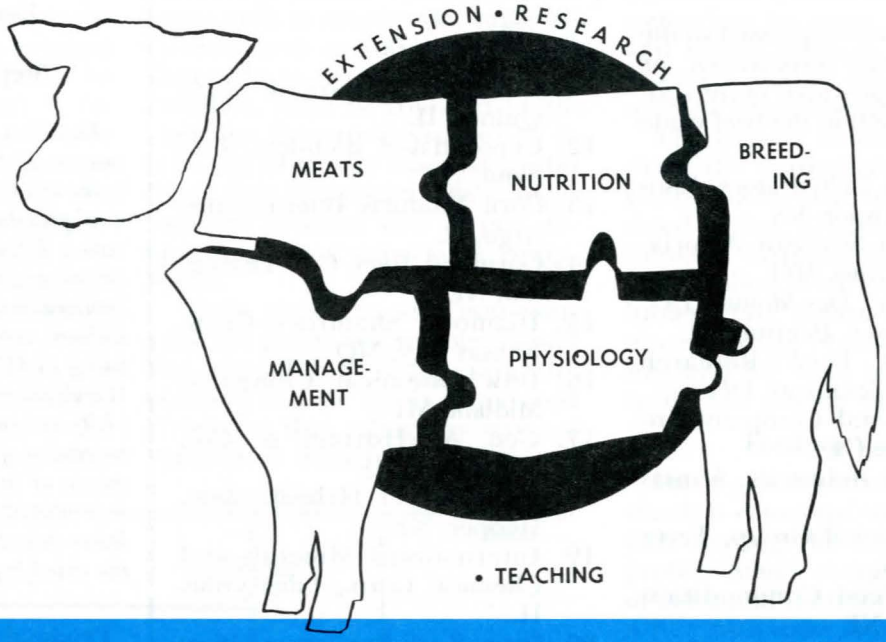

1981 BEEF CATTLE REPORT

Contents

Distillers Byproducts Use—a Review 2
Multiple Weighing Is More Accurate 7
Feeding Value—Fermentation of Corn Silage 8
Alfalfa Silage As a Protein Source 11
Cornstalk Grazing for Weanling Heifers 12
Effects of Rumensin in High Fiber Growing Rations 13
Affect on Steer Diet—Continuous Grazing 17
Range Conditions Affect Diet, Performance 18
Alfalfa Press Cake and Performance 21
Heat Affects Alfalfa Protein 23
Ammoniated Cobs for Growing 25
Corn Mixtures Improve Performance 27
Temperature and Feedlot Performance 29
Potassium Improves Performance 31
Rumensin in Feedlot Rations 32
Acidosis, Mineral Excretion in Lambs—Affects of High Concentrate Diets 33
Spaying and Implanting Growing and Finishing Heifers 35
Excellent Promise—Insecticide-impregnated Eartags 38
Rumensin for Cows 39
Estrous Synchronization Studied 42
Ralgro Implants for Bred Heifers 44
Ammonia Treated Wheat Straw for Cows 45
Dehydratd Alfalfa for Cows 47
Fat Level in Ground Beef 49
A New Concept—Sectioned and Formed Beef Steaks 51
Tenderizing Beef Rounds 52
Industry Genetic Change 54

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Distillers Byproducts

Terry Klopfenstein
and
Stephen M. Abrams[1]

Distillers dried grains are a good source of bypass protein, having a value of at least 173% that of soybean meal protein. Solubles have little bypass value. Fifty percent of the cost of the initial grain can be recovered in the byproducts if bypass is assumed equal to soybean meal while 69% is recovered using 173% the value of soybean meal. Wet distillers byproducts have a low pH (4.0) and rapidly mold. Wet grains can be ensiled if the pH is raised with ammonia or lime and a palatable product is produced. Bypass protein is probably lower in wet and ensiled grains than in the dried byproduct.

Production of Distillers Grains

During the 1970's most industrial alcohol was produced by the direct hydration of ethylene. Interest in fermentation of grain and other agricultural products to produce alcohol for use as a liquid fuel has grown tremendously with the increasing cost of petroleum-derived energy sources. As alcohol plants come into production in the 1980's, large quantities of fermentation byproducts will be produced.

The average annual production of dried distillers byproducts in the U.S. over the last 10 years has been 400,000 tons. Government estimates are that this will rise to 1.8 million tons in 1981, and 6.5 million tons by the mid-1980's. Knowledge of the nutritional quality and handling characteristics of distillers byproducts, and methods to improve their utilization will be essential for both producers and consumers. What follows is a review of recent research conducted on grain-based distillers byproducts at the University of Nebraska.

Several byproducts can be produced during alcohol production. Most commonly, distillers grains and solubles are produced. However, if the grain is wet milled be-

Use—A Review

fore fermentation, corn gluten meal is produced and a product similar to brewers grains can be produced if sugar (wort) is removed from the grains before fermentation. The byproducts are all similar in that much of the protein is undegraded grain protein. Also, a soluble protein is produced in each case. Figure 1 schematically demonstrates how each product is produced.

Two distinct byproducts are produced in the conventional beverage distillery. The first is the portion of corn remaining after fermentation, which is sometimes called mash or wet grains. The second byproduct is thin stillage or distillers solubles. This consists of yeast cells in suspension, sugar alcohols, and organic acids. Both byproducts, the grains and the solubles, must be collected to obtain the theoretical yield of 17 lb (7.7 kg) of air-dry material per bu (l) of corn fermented. The solubles amount to about 40% of this, depending upon processing equipment.

Both physically and nutritionally, the grains and solubles should be considered independently. Grains can be easily separated from the thin stillage by screens, presses, or centrifuges. Dry matter will be 40-70%. The thin stillage, however, is only 5-7% solids, and presents the primary handling and utilization problem. While the grains can be economically dried and moved through normal feed channels, drying the solubles requires a large amount of energy.

The present beverage industry dries the byproducts in several combinations to produce distillers dried grains, condensed distillers solubles, distillers dried solubles and distillers dried grains plus solubles. The products presently move through normal feed channels and are used in beef, dairy, swine, and poultry feeds.

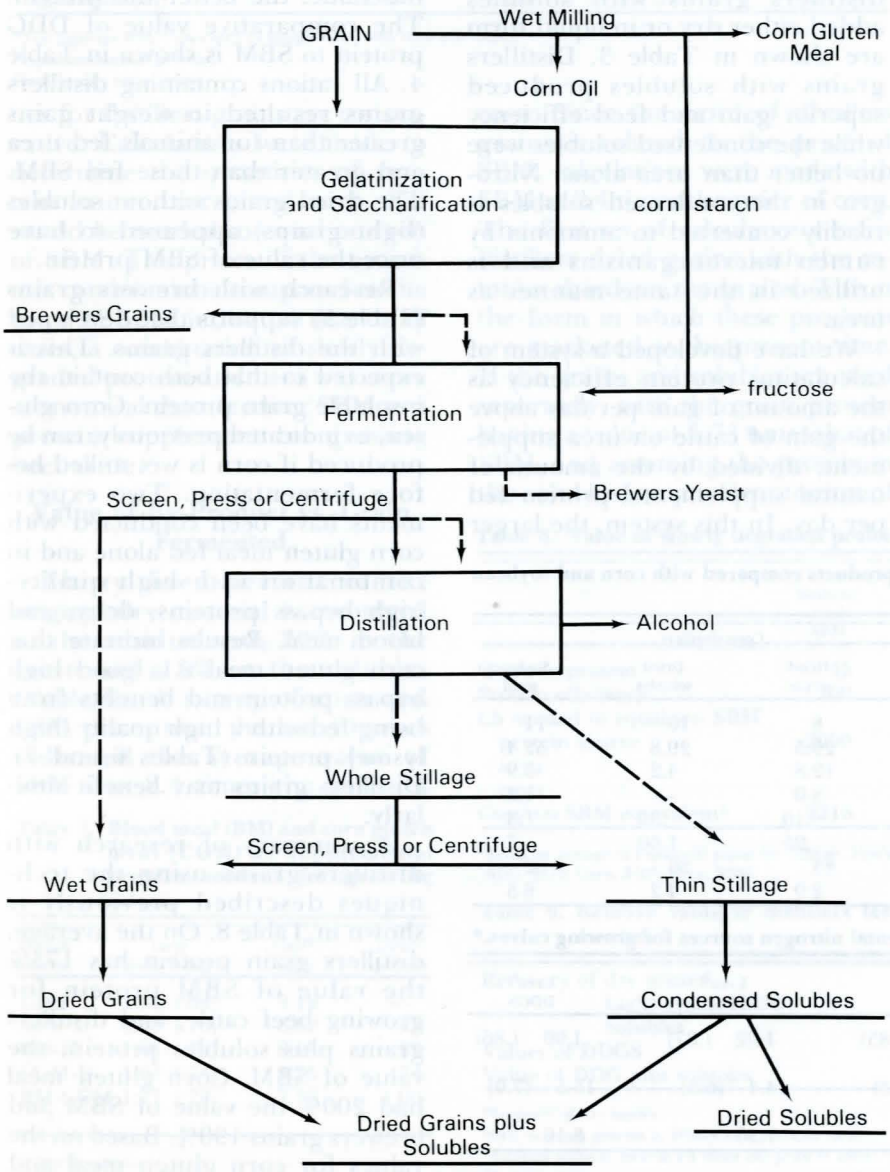

Figure 1. Flow diagram of production of byproducts of alcohol fermentation.

Feeding Value

During fermentation of corn, starch is converted to alcohol and CO_2 leaving the fiber, fat, and protein. Starch comprises about ⅔ of corn, and therefore, content of other nutrients increase about three times in the byproducts. In this process an energy source (corn) has been converted to a protein source. To obtain maximum nutritional (and perhaps economic) use of the byproducts, they should be fed to make use of the protein content, rather than as an energy source.

The value of the protein in distillers byproducts depends upon the characteristics of those proteins, namely the amino acid pattern and protein bypass. For monogastric animals, swine and poultry, amino acid balance is important. Proteins are used in these rations to supplement corn grain. The protein in corn grain is low in lysine (Table 1). Normally, soybean meal is used as the protein supplement because it is a good source of lysine.

Distillers grains are a poor protein source because they contain the same protein as that in the corn. Because the solubles contain some yeast cells, they are higher in lysine than distillers grains, but not comparable to soybean meal. Therefore, distillers byproducts are not especially useful in swine and poultry rations, but the solubles are more valuable than the grains.

(continued on next page)

Distillers Byproducts

(continued from page 3)

Distillers byproduct value for ruminants is based primarily on its bypass value. Bypass protein is that protein which escapes digestion in the rumen and passes intact to the small intestine where it is digested. A series of experiments was conducted at the University of Nebraska to determine the value of dried distillers grains protein for cattle.

The theory was that protein from distillers grains would be worth more than soybean meal (SBM) because the protein in distillers grains resists breakdown by rumen microorganisms. Therefore, some of the protein from distillers grains could be replaced with urea without depressing animal performance. The effects of four protein supplements, SBM, urea, urea + DDG and urea + DDGS on average daily gain (ADG) and feed efficiency are shown in Table 2.

Rate of gain with distillers grains was not much better than urea. Feed efficiency was nearly as good as with SBM but since half of the distillers grain protein had been replaced with urea, this would be a considerable economic savings. Results from another experiment in which urea alone was compared with combinations of urea and distillers grains with solubles added either dry or in liquid form are shown in Table 3. Distillers grains with solubles produced superior gain and feed efficiency while the condensed solubles were no better than urea alone. Nitrogen in the condensed solubles is readily converted to ammonia by rumen microorganisms and is utilized in the same manner as urea.

We have developed a system of calculating protein efficiency as the amount of gain per day above the gain of cattle on urea supplement, divided by the amount of natural supplemental protein fed per day. In this system, the larger the value, the better the protein. The comparative value of DDG protein to SBM is shown in Table 4. All rations containing distillers grains resulted in weight gains greater than for animals fed urea and greater than those fed SBM. The dried grains without solubles (light grains) appeared to have twice the value of SBM protein.

Research with brewers grains (Table 5) supports that developed with the distillers grains. This is expected in that both contain the insoluble grain protein. Corn gluten, as indicated previously, can be produced if corn is wet milled before fermentation. Two experiments have been conducted with corn gluten meal fed alone and in combination with high quality-high bypass proteins, dehy, and blood meal. Results indicate that corn gluten meal is a good high bypass protein and benefits from being fed with a high quality (high lysine) protein (Tables 6 and 7). Distillers grains may benefit similarly.

A summary of research with distillers grains using the techniques described previously is shown in Table 8. On the average, distillers grain protein has 173% the value of SBM protein for growing beef cattle, and distillers grains plus solubles protein, the value of SBM. Corn gluten meal had 200% the value of SBM and brewers grains 190%. Based on the values for corn gluten meal and brewers grains, we feel these val-

Table 3. Performance of growing calves fed urea, distillers dried grains with solubles (DDGS), condensed distillers solubles (CDS) and distillers dried grains with condensed solubles (DDG + CDS).

Ration description	Daily gain, lb (kg)	Feed/gain
Urea	1.42 (.64)	10.34
DDGS – urea	1.95 (.88)	7.57
CDS – urea	1.33 (.60)	11.12
DDG + CDS – urea	1.81 (.82)	8.15

Table 4. Efficiency of protein utilization of distillers dried grains (DDG) and distillers dried grains with solubles (DDGS).

Source	Avg. daily gain, lb (kg)	Gain, lb[a] (kg)	Supplemental protein, lb[b] (kg)	Gain/protein	Comparative value, %[c]
Urea	1.39 (.63)	--			
SBM	1.54 (.70)	.15 (.09)	.29 (.13)	.51	100
DDG	1.69 (.77)	.30 (.14)	.29 (.3)	1.03	200
DDGS	1.66 (.75)	.27 (.12)	.29 (.13)	.93	180

[a]Average daily gain above that of urea control.
[b]Protein from natural supplemental sources per day.
[c]Expressed as a percent of SBM.

Table 1. Nutrient composition of distillers byproducts compared with corn and soybean oil meal.

		Corn distillers		
	Corn grain	Dried grains	Dried solubles	Soybean meal
Moisture, %	11	8	10	11
Protein, %	10	29.5	29.8	52.4
Fiber, %	2.2	12.8	4.2	5.9
Fat, %	3.5	8.0	--	1.3
Calcium, %	.02	.10	.30	.3
Phosphorus, %	.32	.95	1.60	.7
TDN, %	91	83	86	82
Lysine % of protein	2.5	2.9	4.2	6.5

Table 2. Distillers feeds and urea as supplemental nitrogen sources for growing calves.[a]

Item	SBM	Urea	Urea[b] DDG	Urea[b] DDGS
Daily gain, lb (kg)	2.24 (1.02)	1.87 (.85)	1.92 (.87)	1.90 (.86)
Daily feed, lb (kg)	16.4 (7.4)	16.1 (7.3)	14.4 (6.5)	15.5 (7.0)
Feed/gain	7.32	8.61	7.50	8.16

[a]Trial lasted 112 days, 5 individually fed calves/treatment.
[b]Urea supplied 50% of the supplemental nitrogen.

Table 5. Brewers dried grains compared to soybean meal for growing calves.[a]

Supplement	Daily gain, lb (kg)	Feed/gain	Gain/protein[a]
Urea	1.45 (.66)	7.74	--
Soybean meal	1.92 (.87)	6.83	.67
Brewers dried grain — urea	1.93 (.88)	7.09	1.26

[a]106 days ration based on corn silage and 4% NaOH treated corn cobs (50:50). Average weight of cattle was 570 pounds (260 kg).
[b]Gain and protein in excess of urea control.

Table 6. Corn gluten meal and dehy as high bypass proteins.

Item	Protein sources[a]				
	Urea	SBM	Dehy	CGM	Dehy + CGM[b]
Number of animals[c]	19	19	30	19	19
Daily gain, lb (kg)	.90 (.41)	1.02 (.46)	1.18 (.54)	1.12 (.51)	1.20 (.54)
Daily feed, lb (kg)	12.8 (5.8)	12.7 (.58)	13.3 (6.0)	12.8 (5.8)	13.3 (6.0)
Feed/gain	14.2	12.5	11.3	11.4	11.1
Efficiency (gain/protein)		.38	.79	.72	.92

[a]Test proteins 40% – urea 60% of supplement, 60% corn cob ration.
[b]Equal amounts of protein.
[c]Individually fed animals.

ues for distillers grains are conservative. Calculations were made to determine the quantities of protein source, corn, and urea that would be needed to equal one ton of SBM. The prices of these various combinations compared to the price of SBM indicated that in all cases, a combination of slowly degraded protein and urea was more economical than feeding SBM as a protein supplement for growing beef cattle.

Value of By-Product vs. Grain Fermented

Thirty-three percent of the original dry material is recovered in the residue with 20% in the grain and 13% in the solubles (Table 9). A survey of corn and SBM prices over the last 10 years indicated the average value of SBM was 2.4 times the price of corn. Since the price of distillers grains is related to the price of SBM, calculations were made with SBM at 2.4 times the price of corn. The first set of calculations is for distillers dried grains with the solubles dried on the grains. This is the form in which these products are marketed at the present time. If the grains and solubles are used separately, with the grain protein having a value of 1.73 times that of SBM, and assuming the protein in the solubles is equivalent to that of corn on a dry basis, then the second set of values would be obtained. Thus, an estimate would be that when distillers grains are used as protein feeds for cattle, 68% of the value of the original grains will be recovered, if the byproducts are not present in over-supply. If the bypass value is not utilized, and the protein is assumed equivalent to SBM, the recovery would drop to 50%.

Table 7. Blood meal (BM) and corn gluten meal (CGM) as supplemental protein sources for growing calves.

Protein source	Daily gain, lb (kg)	Feed[b]/gain	Gain[c]/protein
Urea	1.41 (.64)	9.19	--
SBM-U	1.55 (.70)	8.62	.47
BM-U	1.66 (.75)	8.13	.83
CGM-U	1.64 (.74)	8.35	.74
BM-CGM -U	1.71 (.78)	7.78	1.00

[a]12 hd/treatment.
[b]Dry matter basis.
[c]Pound of gain and protein in excess of the urea control.

Utilization off Wet Distillers By-products

Up to 40% of the energy used in a distillery is used for drying byproducts. Presently, this amounts to about $50/ton of dry product produced. Especially for "on-farm" stills, drying would probably be economically prohibitive. Because the pH is lowered before fermentation to exclude competitive microorganisms, the byproducts have been found to have a pH of 3.7 to 4.0. This low pH prevents further fermentation or ensiling. If air is not excluded rapid mold growth occurs.

Wet grains will not mold if treated with propionic acid and, presumably, other mold inhibitors. Flushing an airtight container with CO_2 also inhibits mold growth. Ammonia treatment at levels suffi-

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Table 8. Value of slowly degraded protein.

	Soybean meal SBM	Distillers dried grains	Distillers dried grains plus solubles	Corn gluten meal	Brewers grains
% crude protein	45	28	28	62	28
Protein efficiency	100	173	137	200	190
Lb needed to equal ton SBM					
protein source	2000	1853	2346	537	1619
urea		135	87	160	152
corn		12	--	1303	229
Cost/ton SBM equivalent[a]	$215	$141	$169	$150	$116

[a]Based on average of Feedstuffs prices for 7/20/80, 7/28/80 and 8/4/80: SBM, $207; CGM, $243; DDG, $137; DDGS, $137, BDG, $110, Corn, $105; Urea, $200.

Table 9. Relative value of distillers feeds as protein sources compared to grain fermented.

Recovery of dry matter	33%
Light grains (DDG)	20%
Solubles	13%
Values of DDGS	69% (33%[a] × 64%[b] × 2.4[c] × 1.37[d])
Value of DDG plus solubles	68% (20%[a] × 66[b] × 2.4[c] × 1.73[d]) + 13[e]

[a]Recovery of dry matter.
[b]64% as much protein in DDGS as in soybean meal.
[c]Assumes soybean meal is 2.4 times the price of corn.
[d]Protein efficiency value compared to soybean meal.
[e]Solubles equal to corn.

Distillers Byproducts

(continued from page 5)

cient to inhibit biological activity inhibits mold growth, and the residual nitrogen could be used by ruminant animals to compliment the bypass protein from distillers grains. The disadvantage of CO_2 and NH_3 treatment is the need for an airtight container.

The use of either lime or ammonia to moderately increase the pH results in a butyric acid type of fermentation, with an increase in soluble nitrogen (Table 10). Although this type of fermentation is normally associated with palatibility problems in corn silage, this may not occur when the fermented feed constitutes a small percentage of the diet. Dry matter intake of lambs was improved by feeding ensiled wet grains compared to dry grains (Table 11). Nitrogen digestibility was unaffected, although rumen ammonia concentrations were slightly depressed in lambs fed the dried grains, and elevated lambs fed the grains ensiled with NH_3. Thus, the use of conventional silos for wet grain storage may be quite feasible.

Laboratory methods to estimate the amount of bypass protein as a feedstuff are in the developmental stage. Two techniques currently used at the University of Nebraska are *in vitro* ammonia release in which the NH_3 concentration of rumen fluid is measured after inoculation of a feed sample (Table 12), and enzymatic hydrolysis of proteins with a proteolytic enzyme, such as pronase (Table 13). Both techniques suggest that the condensed solubles have a relatively low bypass value compared to the grains which appear considerably higher than SBM, and that drying the grains somewhat increases their bypass value.

Table 12. *In vitro* ammonia release (mg/100 ml) of SBM and distillers byproducts.[a]

Hours post-inoculation	SBM	Condensed solubles	Dry DG	Wet DG	Ensiled wet DG: No additive	Ensiled wet DG: Ca $(OH)_2$
0	2.0	3.7	2.0	2.0	2.2	3.1
12	24.7	13.8	2.4	2.9	3.6	8.0
24	37.4	21.9	10.1	11.7	12.3	15.3

[a]SBM=soybean meal; DG=distillers grains.

Table 13. Percent pronase-degradable nitrogen[a] remaining after inoculation with pronase[b]

Hours post-inoculation	SBM	Condensed solubles	Dry DG	Wet DG	Ensiled wet DG: No additive	Ensiled wet DG: Ca $(OH)_2$
0 (buffer only)	58.8	69.7	81.4	63.4	79.6	64.7
.5	19.7	21.2	51.7	41.8	44.7	35.3
8	4.1	10.6	23.1	17.0	13.8	11.8

[a]%Pronase degradable N=(N residue-N residue 72M)/initial N.
[b]SBM=soybean meal; DG=distillers grains.

Table 10. Analysis of distillers wet grains.

Item	Treatment: Fresh	Ensiled	pH Adjusted
Initial pH	3.9	3.9	6.0
Final pH	3.9	3.9	4.6
Acetate (u moles/g)	16	35	288
Propionate (u moles/g)	0	0	21
Butyrate (u moles/g)	0	2	403
Lactate (% DM)	1.31	1.61	.64
Soluble N[a] (%N)	5.2	14.2	11.5

[a]Burroughs mineral buffer; corrected for NH_3-n.

Table 11. Effect of method of preservation of distillers grains on lamb intake and digestibility.

Item	Treatment[a]: UREA DDG	UREA WDG	UREA EDWG-Sorbate	UREA EWDG-Lime	UREA EWDG-NH_4OH
Dry matter consumption lb (gm)	1.57 (711)	1.49 (675)	1.59 (723)	1.75 (792)	1.61 (732)
Dry matter digestibility, %	53.4	54.8	55.0	56.4	57.3
Nitrogen digestibility, %	66.8	66.6	67.6	65.5	69.9
Rumen ammonia, mg/100 ml	5.45	7.41	7.21	6.83	11.95

[a]DDG=distillers dried grains; WDG=wet distillers grain; EWDG=ensiled wet distillers grains followed by treatment.

Whole stillage or thin stillage may keep, with mold growth occurring only on the surface. It also may be used to reconstitute forages or grains, in which case pH adjustment may be necessary. The primary problem of this byproduct is its high water content. Ninety to 95% of the total water in the whole stillage ends up in the thin stillage. It may be possible to separate the suspended solids and recycle the water. This can be done in the laboratory by centrifuging, but it may not be a practical system commercially. Other systems of removing the solids should be developed in the next year or two. Some settling may occur in a tank such that the suspended solids would be concentrated in the lower ⅓ to ½ of the liquid. The clear liquid on the top could be removed and discarded. As the solids would consist primarily of yeast cells, its protein content on a dry matter basis may be higher than the conventional distillery byproduct, distillers dried solubles.

We recommend that producers with on-farm stills attempt to feed whole stillage mixed into complete beef or daily rations until further technological developments are made in the handling and separation of stillage.

[1]Terry Klopfenstein is Professor, Ruminant Nutrition. Stephen Abrams is a Post-doctoral Research Associate.

Multiple Weighing Is More Accurate

Dennis Brink, John Merrill, Terry Klopfenstein, Russ Olson, Bill Brown[1]

The variation in average daily gain of cattle fed 104 or 112 days in three individual feeding trials, was reduced 2% by using an average of two consecutive daily initial and final individual weights compared to one initial and final weight. An average of weights taken on three and five consecutive days reduced variation 3% and 3.6%, respectively. The variation in daily gain of pen-fed cattle over 118 or 138 days-on-feed was reduced about 12% by using two consecutive daily initial and final weights. The coefficient of variation for gain in 104 or 112 day periods, regardless of weighing procedure (as many as five consecutive daily weighings), was less than that in 56-day periods.

Introduction

Errors in measuring weight gain limit our ability to detect significant treatment differences. Weighing steers three consecutive days at the beginning and end of the trial improved (over single weights at the beginning and end) ability to detect treatment differences in previous research.

Many treatments need to be evaluated over a short period of time. This is especially true of protein studies with the growing calf whose protein requirement decreases rapidly. In the following growing trials different weighing methods were used to test the value of multiple weighings to decrease variation in gain measured over short and long periods.

Individual Feeding Trials

Sixty crossbred steers in each of three trials were individually fed using electronically controlled gates in an open front barn with a gutter flush system. Each trial was designed to evaluate different protein sources in addition to weighing procedures. Trials 1 and 2 lasted 112 days and Trial 3 lasted 104 days. In Trial 1 cattle were weighed on five consecutive days at the beginning and end of the trial and at 56 days. Weighings for Trial 2 were the same as Trial 1 except weights were taken on three consecutive days only. Cattle in Trial 3 were weighed on three consecutive days at the beginning and end of the trial.

The coefficient of variation (CV) is a statistic which indicates the amount of variation in a sample relative to the mean of the sample. As the CV decreases, the number of animals required to detect a treatment difference decreases. When the number of observations remain constant, but the CV decreases, small treatment differences can be detected.

Coefficients of variation for ADG over the entire trial (112 or 104 days) using standard weighing procedure (one initial and final weight) were 12.12%, 9.96% and 13.58% for Trials 1, 2 and 3, respectively (Table 1). When results of the three trials are pooled, an average of two consecutive weights and an average of three consecutive weights reduced the CV 2.30 and 3.07%, respectively. Results of four and five day averages in Trial 1 were not consistent and the five day average resulted in only a 3.6% reduction in the coefficient of variation.

When the coefficients of variation using a single weight at the beginning and end were pooled across trials, values were greater (15.6 vs 11.9) for shorter (56 days) periods than the entire trial (112 or 104 days). Although additional weights at the beginning and end of 56 day periods reduced the variation (Table 1), gain measured over 104 and 112 days was always less variable than gain measured

(continued on next page)

Table 1. Coefficients of variation (%) for average daily gain in individual feeding trials using different weighing methods.

	Trial 1[b]			Trial 2[c]			Trial 3[d]
Weighing method[a]	Period I (56 days)	Period II (56 days)	Entire trial (112 days)	Period I (56 days)	Period II (56 days)	Entire trial (112 days)	Entire trial (104 days)
1	15.88	16.56	12.12	15.04	15.07	9.96	13.58
2	15.40 (3.0)[e]	14.30 (13.6)	11.99 (2.0)	13.19 (12.8)	14.34 (4.8)	9.61 (3.4)	13.37 (1.6)
3	14.21 (10.5)	15.03 (9.2)	11.84 (2.3)	13.11 (12.3)	13.98 (7.2)	9.54 (4.2)	13.23 (2.6)
4	14.28 (10.1)	15.45 (6.8)	12.30 (-1.5)				
5	13.51 (14.9)	16.02 (3.2)	11.68 (3.6)				

[a]Number of initial and final weights taken on consecutive days.
[b]Trial 1—Initial weight 522 lb (237 kg); ADG 1.44 lb (.65 kg)/day, 60 animals.
[c]Trial 2—Initial weight 490 lb (233 kg); ADG 1.58 lb (.72 kg)/day, 60 animals.
[d]Trial 3—Initial weight 484 lb (220 kg); ADG 1.84 lb (.84 kg)/day, 60 animals.
[e]Percent reduction in coefficient of variation by using multiple weights.

Multiple Weighing

(continued from page 7)

Table 2. Coefficients of variation (%) for average daily gain in pen fed cattle using two weighing methods.

Weighing method[a]	Trial 1[b] (138 days)	Trial 2[c] (118 days)
1	5.6	7.8
2	4.9 (12.5[d])	6.9 (11.5[d])

[a]Number of initial and final weights taken on consecutive days.
[b]Trial 1—Initial weight 516 lb (235 kg), 1.35 lb (.61 kg)/day, 144 animals.
[c]Trial 2—Initial weight 490 lb (223 kg), 2.2 lb (1.0 kg)/day, 192 animals.
[d]Percent reduction in coefficient of variation by using multiple weights.

over 56 day periods, regardless of weighing procedure.

Pen Feeding Trials

Weighing on two consecutive days at the beginning and end of the trial was evaluated in two trials involving pen-fed cattle. Trial 1 consisted of 144 crossbred calves averaging 516 lb (235 kg) and randomly allotted to 18 pens. In Trial 2, 192 crossbred calves weighing 490 lb (221 kg) were allotted to 12 pens. Length of trial (days) and ADG [lb (kg)/day] of cattle were: 138, 1.35 (.61) and 118, 2.2 (1.0) for Trial 1 and 2, respectively.

Although the coefficients of variation for pen-fed trials (Table 2) were lower than individual feeding trials (approximately 7% vs 12%), more cattle (144 or 192 vs 60) were required. Coefficients of variation for gain calculated using one versus average of two initial and two final weights were 5.6 vs 4.9 (Trial 1) and 7.8 vs 6.9 (Trial 2). The additional weighing at the beginning and end of the trials reduced variation about 12%.

Two consecutive daily weighings at the beginning and end of individual and pen-feeding trials appear to be beneficial in reducing variation in gain. However, longer trials have less variation in ADG than shorter trials, regardless of weighing procedure used.

[1]Dennis Brink is Assistant Professor, Ruminant Nutrition. Terry Klopfenstein is Professor, Ruminant Nutrition. John Merrill, Russ Olson and Bill Brown are Graduate Assistants.

Silage was stored in silopress bags.

Feeding Value

Fermentation of Corn Silage

Terry Klopfenstein, John Merrill, Robert Britton, Lyle Petersen and Dave Pankaskie[1]

Fermentation of corn silage was increased by addition of limestone and ammonia and decreased by additions of sulfite liquor plus phosphoric acid. Microbial innoculums or enhancers did not increase fermentation. None of the treated silages improved performance over the control silage.

Introduction

Lactic acid fermentation is necessary for proper ensiling. However, some energy may be lost and proteins are usually degraded in this fermentation. Both increased and decreased amounts of fermentation have been proposed as means of increasing the efficiency of silage fermentation and quality of the remaining product. Silage additives are available which can produce each of these effects. Lactic acid organisms, microbial enhancers, or buffers all increase fermentation while acid compounds decrease it. These experiments were conducted to measure cattle response to silages with varying degrees of fermentation.

Procedure

Trial 1

Chopped corn plant containing 34% dry matter was ensiled in silopress bags. Four treatments were used with two bags of each treatment. Additives were distributed on the top of loads of chopped corn plant in front-unloading forage wagons. Mixing took place during unloading and pressing in the bags. Treatments were: (1) control, (2) siloseed treated, (3) siloseed plus limestone and (4) sulfite liquor plus 10% phosphoric acid.

Siloseed, a microbial enhancer, was added at the rate of 15 lb/ton (.5 kg/MT) of wet silage. Limestone, a buffer, was added at the rate of 15 lb/ton (7.5 kg/MT). The sulfite liquor-phosphoric acid mixture was added at the rate of 90 lb per ton (45 kg/MT). The mixture contained 10% phosphoric acid and lowered the pH of the corn plant material to 3.8 before fermentation. Sulfite liquor is a byproduct of the wood pulping industry. It is relatively low in pH and contains phenolic compounds which could complex proteins. A temperature sensing unit was placed in each bag at ensiling time.

Two hundred Angus, Hereford and Charolais cross steers averaging 480 lb (218 kg) were allotted by weight within breed to 8 pens, 25 animals per pen, with 2 pens receiving each treatment. Animals were fed once daily a complete mixed ration consisting of 92% corn silage, 6.5% liquid supplement, and 1.5% dry supplement containing monensin (dry basis). Non-protein nitrogen supplement was used to stress the protein in the silages. Daily feed intakes were recorded for each pen and individual animal weights were recorded at the beginning and end of the 119-day trial following 16 hours without feed or water.

Results. The addition of siloseed had no appreciable effect on the

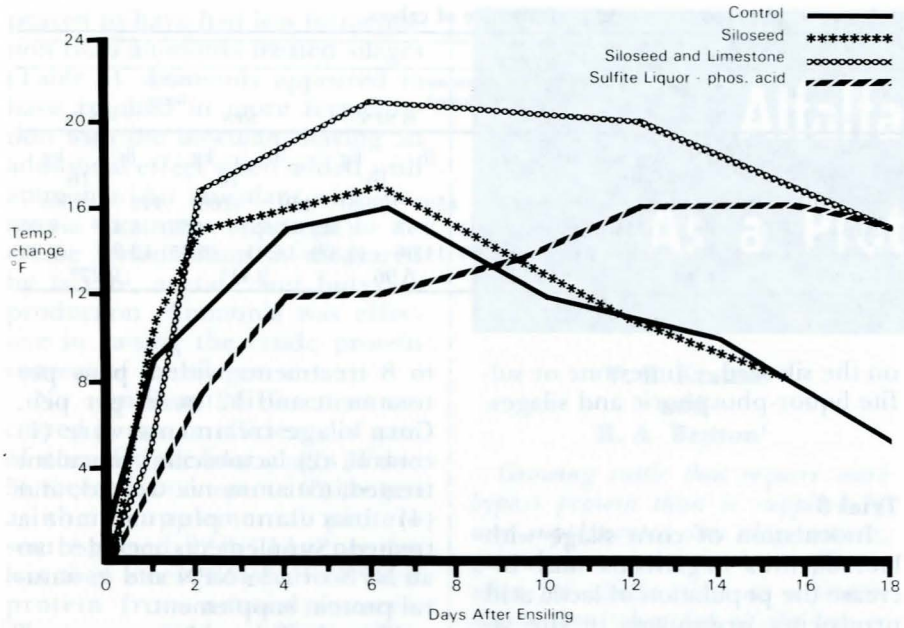

Figure 1. Effect of fermenting silage on temperature rise.

temperature rise of the fermenting silage (Figure 1). Silage treated with both siloseed and limestone showed a greater temperature rise than siloseed alone or control and declined from this peak more slowly. This indicates a greater degree of bacterial fermentation in the siloseed + limestone treated silage.

Sulfite liquor-phosphoric acid reduced the pH of the corn plant material to 3.8 at ensiling. This appeared to slow the rate of fermentation during the first week after ensiling. However, the temperature of sulfite liquor treated silage continued to rise after day 6 when the temperature of the other three silages had begun to decline.

Table 1. The effect of silage treatments on performance of calves.

	Treatment							
	Control		Siloseed		Siloseed + limestone		Sulfite liquor + phos. Acid	
	lb	kg	lb	kg	lb	kg	lb	kg
No. steers	49		48		49		48	
In. weight	484	(220)	494	(224)	476	(216)	482	(219)
Daily gain	1.36[a]	(.62)	1.34[a]	(.61)	1.04[b]	(.47)	1.35[a]	(.61)
Daily DM intake	13.9	(6.3)	13.2	(6.0)	12.6	(5.7)	13.1	(6.0)
Feed efficiency	10.2		9.9		12.1		9.8	

[a]Means in the same row with different superscripts are different P<.05.

Table 2. Analyses of silages and fresh chop from Trial 2.

	Dry matter %	Protein %	IVDMC[a] %	pH	Lactate %	Acetate %	Butyrate %
Fresh cut corn plant	29.4	7.5	71.8	5.2	0.90	.52	.05
Control Corn silage	29.8	7.9	69.1	3.9	4.91	1.69	0.09
Siloseed Corn silage	30.6	7.9	68.5	3.9	8.96	1.63	0.03
Siloseed & lime Corn silage	30.0	8.0	67.0	4.3	5.83	3.21	--
Sulfite liquor Fresh cut corn Plant	30.0	10.4	72.4	4.1	0.29	0.20	--
Sulfite liquor Corn silage	30.5	9.7	69.9	3.8	2.68	0.87	--

[a]In vitro dry matter disappearance.

The peak temperature change for sulfite liquor was +16°F, (9.6°C), the same as control, and this temperature was maintained for at least four days compared to an immediate decline for both siloseed treated and control silages. While the acidic material (sulfite liquor) may have inhibited fermentation during the first week after ensiling, it was not a longterm effect.

Performance of cattle fed control, siloseed, and sulfite liquor treated silage was nearly identical (Table 1). Cattle fed silage treated with siloseed and limestone ate less feed and gained more slowly than cattle on the other three treatments.

Trial 2

In Trial 2, corn silage treatments were identical to treatments in Trial 1. However, in Trial 2 each of the four experimental silages were fed in combination with an all NPN supplement and with a supplement that was half of the nitrogen from NPN and half from natural protein. Natural protein was supplied by corn gluten meal and blood meal on a one-to-one basis. Monensin was included in the supplements to provide 30 g/ton of feed (33 gm/MT).

Steers of mixed breeding weighing an average of 450 lb (205 kg) were allotted to 16 pens with 8 steers per pen with 2 pens per treatment. The trial lasted 128 days.

Samples of fresh chopped corn plant were taken at ensiling before treatments were applied and after sulfite liquor was applied. While the silages were being fed, samples were taken for laboratory analysis.

Results. Siloseed and siloseed + limestone silages showed a more extensive fermentation than control and sulfite liquor treated corn silages as measured by lactate, acetate, and butyrate production (Table 2). The pH of fresh cut material was lowered more than 1.0 unit by treatment with sulfite liquor plus phosphoric acid, however, final pH after fermentation was similar between the control and sulfite liquor-phosphoric acid

(continued on next page)

Table 3. The effect of silage treatment and supplemental nitrogen source on performance of calves.

	Silage treatment and protein source															
	Control				Siloseed				Limestone & siloseed				Sulfite liquor			
Item	NPN		½ NPN		NPN		½ NPN		NPN		½ NPN		NPN		½ NPN	
	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg
No. steers	16		16		16		16		15		16		16		16	
Init. wt.	444	(201)	448	(203)	443	(201)	451	(205)	454	(206)	459	(208)	459	(208)	442	(200)
Daily gain	2.10	(.95)	2.32	(1.05)	2.13	(.97)	2.28	(1.03)	2.01	(.91)	2.03	(.92)	1.52[a]	(.69)	1.43[a]	(.65)
Daily DM intake	14.67	(6.65)	14.66	(6.65)	14.64	(6.64)	14.63	(6.64)	14.51	(6.58)	14.06	(6.38)	14.01	(6.35)	13.28	(6.02)
F/G	7.00		6.34		6.86		6.44		7.21		6.96		9.41[a]		9.27[a]	

[a]Silages were different at .05 level.

Fermentation of Corn Silage

(continued from page 9)

corn silage. By lowering the pH of the corn plant material through addition of sulfite liquor and phosphoric acid at ensiling the amount of fermentation was lowered.

Steers fed sulfite liquor-phosphoric acid treated corn silage gained significantly less than steers fed the other three corn silages (Table 3). They also ate less feed and were less efficient. Reducing fermentation during ensiling by treatment with sulfite liquor phosphoric acid did not appear to produce a superior corn silage.

Limestone addition to siloseed treated corn silage resulted in reduced gain and feed efficiency compared to steers fed siloseed treated silage.

Siloseed as a silage additive did not result in improved rate or efficiency of gain. There was a response to natural protein on the control and siloseed silages but not on the siloseed + limestone or sulfite liquor-phosphoric and silages.

Trial 3

Inoculation of corn silage with lactobacillus organisms may increase the population of lactic acid producing organisms in the silages. The pH may be lowered more rapidly and consequently the fermentation may be arrested sooner.

Ammonia has been used as a source of nitrogen and as a fermentation aid in ensiling. The high initial pH caused by the ammonia may be detrimental to lactobacillus organisms, therefore, inoculation with added organisms in combination with ammonia treatment may produce an additive response.

For this trial, steers predominately of Hereford, Angus and Hereford X Angus breeding and averaging 488 lb (222 kg) were implanted with Ralgro and allotted to 8 treatments with 2 pens per treatment and 12 steers per pen. Corn silage treatments were (1) control, (2) lactobacillus inoculant treated, (3) ammonia treated, and (4) inoculant plus ammonia treated. Supplements included an all NPN or a ½ NPN and ½ natural protein supplement.

The silage inoculant contained selected lactic acid-producing and flavor-enhancing bacteria with supporting enzymes for inoculation of silage. It was applied at the recommended level of 1 oz. per 10 ton (28 gm/9090 kg) of wet material. Ammonia was applied to corn plant material at the rate of 7 lb per ton (3.5 kg/MT) of freshly chopped corn plant with a cold flo system. The combination treatment of inoculant and ammonia were applied at the rates applied when used individually. All silages were ensiled at about 30% DM in silopress bags.

The NPN supplement was a liquid (molasses-urea) while natural protein fed was corn gluten meal and blood meal fed to supply equal quantities of protein. Monensin (30 gm/ton [33 gm/MT]) was included in the dry supplement of all rations.

Results. The control corn silage and innoculum treated silage ap-

Table 4. Laboratory analyses of silages in Trial 3 (% of dry matter).

	Dry matter	Lactate %	Protein %	IVDMD[a] %	pH	Acetate %	Butyrate %
Control	33.8	3.9	8.0	72.0	4.0	1.1	0.02
Inoculant	32.7	4.0	7.7	69.9	4.0	1.32	0.03
Inoculant &NH_3	29.0	5.1	15.1	71.0	4.3	2.2	0.25
NH_3	29.8	4.1	12.8	71.0	4.4	2.0	0.28

[a]In vitro dry matter disappearance.

Table 5. The effect of silage treatment and protein source on performance of calves in Trial 3.

Silage treatment:	Control				Inoculant				Inoculant & ammonia				Ammonia			
Nitrogen source:	NPN		½ NPN		NPN		½ NPN		NPN		½ NPN		NPN		½ NPN	
	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg
No. steers	24		24		24		24		24		24		24		24	
Init. wt.	490	(222)	489	(222)	490	(222)	493	(224)	473	(215)	489	(222)	489	(222)	488	(221)
Daily gain[a]	1.96	(.89)	2.32	(1.05)	2.09	(.95)	2.21	(1.00)	2.28	(1.03)	2.18	(.99)	2.03	(.92)	2.40	(1.09)
Daily DM intake	13.84	(6.28)	13.95	(6.33)	12.89)	(5.85)	13.27	(6.02)	14.14	(6.41)	13.27	(6.02)	13.41	(6.08)	13.31	(6.04)
F/G[a]	7.05		6.01		6.30		6.10		6.21		6.12		6.63		5.61	

[a]Protein sources were different (P<.05).

peared to have had less fermentation than ammonia treated silages (Table 4). Ammonia appeared to have resulted in more fermentation with the inoculant having an additional effect when added with ammonia. An inoculant with ammonia treatment appeared to increase fermentation as measured by lactate, acetate and butyrate production. Ammonia was effective in raising the crude protein content of the silages.

No significant differences occurred in rate or efficiency of gain of steers fed the four silages (Table 5). Steers fed non-protein nitrogen as their supplemental protein source gained .22 lb (.1 kg) per day less than steers fed half of their protein from natural sources. They were also less efficient than steers fed natural protein.

Discussion

Laboratory analysis in Trials 2 and 3 and temperature readings in Trial 1 indicate that silages of varying degrees of fermentation were produced. While there were some differences in cattle performance, no treatment was better than the control silage. It should be noted that these silages were well preserved in silopress bags. However, whatever the storage system employed, if good management practices are used, there is probably little need for using a silage additive. These practices include moisture between 60 and 70%, fine chopping, good packing, rapid silo filling and rapid feeding.

Protein value of silages of varying degrees of fermentation appeared similar. Even though increased silage fermentation has been shown to increase crude protein solubility, it is possible that the protein would have been degraded in the rumen anyway. Protein appeared to be limiting in the NPN supplemented silages as there was a response to feeding, corn gluten meal and blood meal.

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[1]Terry Klopfenstein is Professor, Ruminant Nutrition. Robert Britton is Associate Professor, Ruminant Biochemist. John Merrill and Dave Pankaskie are Graduate Assistants, and Lyle Petersen is a former Graduate Assistant.

Alfalfa Silage As a Protein Source

V. E. Krause
and
R. A. Britton[1]

Growing cattle that require more bypass protein than is supplied by urea-supplemented corn silage rations, gained more and were more efficient when fed alfalfa silage as a protein source than when fed alfalfa hay or haylage. When additional bypass protein was not needed, no difference was observed in gain or efficiency of steers fed alfalfa hay or silage.

Introduction

Nebraska weather conditions, particularly in the eastern portion, are not always conducive to hay curing. Delays in harvesting due to wet weather can reduce the quality of alfalfa hay and slow regrowth of the next cutting.

Compared to harvesting alfalfa as haylage or hay, wilted silage has the advantage of reduced dry matter loss in the field, decreased chance of storage losses, lessened dependence on dry weather during harvesting, faster removal of the crop from the field, as well as improved feeding value compared to haylage or hay when fed in corn silage rations.

Alfalfa at about 1/10 bloom was windrowed, crimped and allowed to dry. Alfalfa was field chopped at 30% (silage) and 60% (haylage) dry matter and ensiled in above ground piles covered with plastic. Alfalfa was harvested as stacked hay (85% dry matter), then chopped to about the same length as the ensiled alfalfa before feeding.

Five Experiments

Rations utilizing alfalfa silage or haylage as a source of supplemental nitrogen were fed to growing steers in five experiments (Table 1). Rations were based on corn silage, supplemented with vitamins, salt and minerals.

Soybean meal and urea-supplemented corn silage rations were added to test cattle response to bypassed protein. Since energy content of soybean meal and urea rations were equal, any increase in gain and efficiency of steers fed

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Table 1. Composition of rations in Trials 1-5.

Ingredient (%)[a]	Trials 1	2[b]	3	4[c,d]	5[c]
Alfalfa rations					
Corn silage[e]	68.13	58.48	78.50	77.05	81.39
Alfalfa hay, haylage or silage	29.71	35.78	21.28	19.14	18.38
Minerals and vitamins[f]	2.16	5.74	.23	3.81	.23
Soybean meal rations					
Corn silage[e]	91.36	85.00	94.3	90.96	94.3
Soybean meal	6.35	8.92	4.88	5.08	4.88
Minerals and vitamins[f]	2.29	6.08	.82	3.96	.82
Urea rations					
Corn silage[e]	91.74	86.32	95.18	91.88	95.18
Urea supplement	5.88	7.49	3.90	4.08	3.90
Minerals and vitamins[f]	2.39	6.19	.92	4.04	.92

[a] Percentage of ration on a dry basis. Ingredient cost (¢) per dry lb (kg); corn silage, 2.57 (5.65); alfalfa, 2.35 (5.18); minerals and vitamins, 13 (28.6); soybean meal, 8.89 (19.6); urea supplement (18.5% urea, 81.5% corn) 6.25 (13.8)
[b] Rumensin fed to supply 200 mg/hd/day.
[c] Alfalfa haylage was not used in these trials.
[d] Rumensin fed to supply 180 mg/hd/day.
[e] Dry matter for corn silages in trials 1-5 were 36.8, 44.1, 46.7, 55.0 and 46.7 percent, respectively.
[f] Calcium, phosphorus, trace minerals and vitamin A. Salt fed free choice.

Alfalfa Silage

(continued from page 11)

soybean meal, over that of steers fed urea, was likely due to bypassed protein.

Energy content of the alfalfa-corn silage rations was also equal. Therefore, any response in cattle performance was likely due to bypassed protein. Because soybean meal and urea control rations contained more energy than the alfalfa rations, performance of cattle fed an alfalfa ration should have been less than the controls.

Rations in Trials 1, 2 and 4 were formulated to contain 11.5% protein, .3% phosphorus and .45% calcium. Rations in Trials 3 and 5 contained 11.0% protein, .3% phosphorus and .45% calcium.

In three trials, steers fed soybean meal gained more and were more efficient than steers fed urea (Table 2). In these trials steers fed alfalfa silage rations also gained more and were more efficient than steers fed hay or haylage rations suggesting that alfalfa silage bypassed more protein to the small intestine than hay or haylage.

Feed Costs

Steers fed alfalfa silage had the same feed cost per gain as steers fed soybean meal. Steers fed hay, haylage, or urea had feed cost per gain of 3 to 4¢ higher than steers fed alfalfa silage or soybean meal.

In Trials 4 and 5, there was no difference in gain or feed efficiency between steers fed soybean meal or urea, indicating that urea satisfied the protein requirements of these steers (Table 3). Only slight differences occurred in gain or efficiency between steers fed alfalfa silage or hay. Feed costs were not appreciably different for any treatment.

These data indicate that alfalfa silage is equal or superior to alfalfa hay or haylage when fed with corn silage. The advantages of both harvesting and feed value of alfalfa silage compared to alfalfa hay or haylage show silage to be a more efficient and timely method of harvest.

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[1]Vernon Krause is Assistant Professor, Animal Science, Northeast Station. Robert Britton is Associate Professor, Ruminant Biochemist.

Table 2. Performance of steers fed alfalfa harvested at three moisture levels vs soybean meal or urea in Trials 1, 2 and 3.

	Treatments[a]				
Item	Hay	Haylage	Silage	SBM	Urea
Daily gain, lb[b]	1.83	1.79	2.01	2.18	1.96
(kg)	(.83)	(.81)	(.91)	(.99)	(.89)
Daily feed, lb[c]	17.73	16.58	16.47	15.96	16.38
(kg)	(8.04)	(7.52)	(7.47)	(7.24)	(7.43)
Feed/gain[c]	9.59	9.26	8.22	7.30	8.24
Feed cost/gain, ¢/lb[c]	26.45	25.51	22.63	23.18	25.57
(¢/kg)	(58.31)	(56.24)	(49.89)	(51.10)	(56.37)

[a]Trial 1, 84 days; trial 2, 104 days; trial 3, 84 days.
[b] Initial weight; trial 1, 644 lb (292 kg), 9 steers/lot, 2 lots/treatment; trial 2, 419 lb (190 kg), 10 steers/lot, 2 lots/treatment; trial 3, 657 lb (298 kg), 9 steers/lot, 2 lots/treatment.
[c]Ration composition and ingredient costs are in Table 1.

Table 3. Performance of steers fed alfalfa harvested at two moisture levels vs soybean meal or urea in Trials 4 and 5.

	Treatments[a]			
Item	Hay	Silage	SBM	Urea
Daily gain, lb[b]	2.38	2.45	2.69	2.67
(kg)	(1.08)	(1.11)	(1.22)	(1.21)
Daily feed, lb[c]	16.4	16.3	16.1	16.5
(kg)	(7.44)	(7.38)	(7.29)	(7.49)
Feed/gain[c]	6.90	6.69	6.00	6.25
Feed cost/gain, ¢/lb[c]	18.87	18.29	18.78	18.57
(¢/kg)	(41.60)	(40.32)	(41.40)	(40.94)

[a] Trial 4, 104 days; trial 5, 98 days.
[b] Initial weight; trial 4, 489 lb (222 kg), 8 steers/lot, 2 lots/treatment; trial 5, 525 lb (238 kg), 9 steers/lot, 2 lots/treatment.
[c] Ration composition and ingredient costs are in Table 1.

Cornstalk Grazing for Weanling Heifers

Dan B. Faulkner and John K. Ward[1]

Weanling heifers grazing cornstalks supplemented with 2 lb (.9 kg) of a 32 percent protein supplement gained about 1 lb (.45 kg) per day. Total field grazing required less labor and materials than strip grazing and resulted in slightly higher gains (not significant). No differences in gain were observed for calves of different initial weights, and no sickness was observed during trials.

Introduction

Cows and yearling heifers will gain weight while grazing cornstalks and milo stubble. The weight gain of weanling calves grazing cornstalks has not been determined in Nebraska. Two trials were conducted during the winters of 1978-79 and 1979-80 to determine the weight gains of weanling heifers grazing cornstalks and to determine the effect of strip grazing on calf performance.

Experimental Design

In the first year, 96 Angus x Hereford heifers were randomly allotted to four groups. A 96-acre (40 ha) cornstalk field was divided into four equal areas and the groups randomly allotted to each area. Two of the groups grazed their entire area throughout the trial. The other two groups were allowed to graze one-fourth every two weeks by moving electric fences. The calves were bunk fed 2 lb (.9 kg) per head daily of a pelleted supplement (Table 1) containing 32% natural protein, 1.3%

Table 1. Formulation of pelleted supplement fed to heifer calves.

	Total ration %	Protein %	Ca %	P %	Vit. A IU (000)
Soybean meal	51	24.5	.184	.383	--
Dehy	46.9	7.9	.671	.122	1501
Vit. A supplement	.1	--	--	--	1262
Dical	2	--	.480	.386	--
	100	32.4	1.335	.891	2863

Table 2. The effect of type of cornstalk grazing on average daily gain of weaning heifers[a].

	Total field grazing	Strip grazing
	Average daily gain	
	lb (kg)	lb (kg)
Days 1-28	1.26 (.57)[b]	.84 (.38)[c]
Days 28-56	.92 (.42)[b]	1.12 (.51)[b]
Days 1-56	1.09 (.50)[b]	.98 (.45)[b]

[a]Averaged over both years.
[b,c]Unlike superscripts in a row differ significantly (P<.05)

calcium, 0.9% phosphorus and 2863 IU of vitamin A/lb (1300/kg). The calves were shrunk overnight and weighed at the beginning of the trial, after four weeks and at the end of the trial (eight weeks). The trial was conducted from November 9, 1978, to January 4, 1979. Stalks were covered with snow from January 1 to January 3 so the calves were fed 5 lb of alfalfa-bromegrass hay per head per day during this time in addition to the supplement.

Stalks were from corn that yielded 70 bushels per acre (4456 kg per ha) harvested about one week before the calves were started on trial.

During the second year the trial was conducted in the same field and in a similar manner to the first trial. The only difference was that 80 head of weanling heifers were used and that the calves grazed from November 13, 1979, to January 8, 1980. The corn yielded 70 bushels per acre (4465 kg per ha).

Results and Discussion

Results were pooled over both years (Table 2) with weanling heifer calves grazing cornstalks gaining about 1 lb (.45 kg) per day when 2 lb (.9 kg) of protein supplement was fed.

Total field grazing increased daily gain by .42 lb (.19 kg) the first four weeks of the trial. During the second four weeks the strip grazed heifers gained slightly more than heifers grazing the whole field. This trend resulted in no overall significant difference in ADG between strip grazing and total field grazing; however, the calves grazing the total field tended to outperform the strip-grazed calves by about .1 lb (.05 kg). Due to the increased labor and materials required to strip fence a field and with no improvement in performance of the strip grazed calves, it appears that calves should be allowed access to the total field.

When the calves were broken down to initial weight classes the initial weight had no significant effect on calf gain; however, the heavier weight calves tended to gain slightly more than light weight calves (Table 3).

[1]Dan Faulkner is a Graduate Assistant. John Ward is Professor, Beef Nutrition.

Table 3. The effect of initial weight on average daily gain of weanling heifers[a] grazing cornstalks.

Initial weight		Days 1-28	Days 28-56	Days 1-56
		Average daily gain		
lb	kg	lb (kg)	lb (kg)	lb (kg)
<399	<182	.98 (.45)	.93 (.42)	.95 (.43)
400-499	182-204	1.01 (.46)	1.08 (.49)	1.04 (.47)
450-499	205-227	1.08 (.49)	1.04 (.47)	1.06 (.48)
>500	>227	1.25 (.57)	1.07 (.49)	1.16 (.53)

[a]Averaged over both years and both types of grazing.

Effects of Rumensin in High Fiber Growing Rations

Tom Trotter, Russ Olson, Bill Brown, Terry Klopfenstein, Dennis Brink, and Rick Stock[1]

Rumensin increased gains and feed efficiency in a high fiber beef growing ration at lower levels of protein supplementation but the response decreased as the level of soybean meal supplementation approached the animals protein requirement. There was no response to rumensin in urea supplemented rations. Heating of soybean meal did not improve calf performance.

Gains, feed intake and feed efficiency were higher for steers fed early harvest stalklage than for those fed late harvest stalklage. Rumensin appeared to enhance fiber utilization at low levels but this response was lost at higher levels (30 gm/ton). Low level rumensin (100 mg/day) increased gains and feed efficiency of rations supplemented with both corn and soybean hulls but at 200 mg/day gains were reduced on the soyhull ration.

Introduction

If, in the future, grains are used for human food, monogastric animals and alcohol fuel production, ruminants may be more dependent upon lower quality forages in parts of the beef production cycle. A small increase in efficiency of energy utilization of forages such as crop residues, winter range and low quality hays could have a pronounced effect on animal performance and economics of beef production.

Rumensin has been shown to be an effective feed additive in beef finishing rations and high quality forage (corn silage, alfalfa or

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Effects of Rumensin

(continued from page 13)

grass) based growing rations. Rumensin increases feed efficiency by decreasing the acetate: propionate ratio which increases efficiency of energy utilization. Theoretically, this effect should be maximized on high fiber rations which normally produce high levels of acetate. This has not been consistently observed.

Rumensin and Protein

Two trials were conducted to compare performance of growing steers fed three levels of supplemental protein, two sources of soybean meal, and two levels of rumensin. Sixty Hereford x Angus steers per trial were stratified by weight and randomly allotted to treatment and pens in an individual feeding (using electronically controlled gates) barn. There were 5 steers per level of natural protein and 10 steers fed urea supplements.

The ration was 60% corn silage, 30% corn cobs and 10% supplement. The supplement was designed to supply 11.5% crude protein. Supplements contained the following protein:urea combinations: 1) 100% *urea, 2) 50%* urea, 50% soybean meal, and 3) 75% urea, 25% soybean meal. Rumensin was fed at 0 or 200 milligrams per head per day. The steers were implanted with Ralgro at the beginning of the trial. Soybean meal sources were regular soybean meal (RSBM) and heated soybean meal (HSBM). HSBM was heated under 10 lb of pressure at 121°C for 20 minutes and had a protein dispersibility index of 14. RSBM had a protein dispersibility index of 40.

Weights were taken three consecutive days at the beginning and end of Trial I. Trial II used five consecutive weights at the beginning, middle, and end.

Protein efficiency (a means of evaluating protein on the basis of gain) was calculated as average daily gain (of steers fed the test protein) above the gain of urea control steers, divided by the amount of supplemental natural protein.

Results

Rumensin produced no increase in gain or feed efficiency when fed with the urea control (Table 1). This indicates that rumensin does not increase microbial protein synthesis and is consistent with basic research from our laboratories. Because protein is first limiting, any effect of energy utilization would probably not be expressed. There was no response to heating of the soybean meal (HSBM vs RSBM) and the two sources responded similarly to rumensin.

In both trials, calves responded to the higher level of protein supplementation (50%) indicating that the 25% level was limiting in natural protein. Response to rumensin was greater at the 25% level of protein than at the 50% level, especially in Trial 1. This indicates a protein sparing effect.

As the level of protein approaches the animal's requirement, the response to rumensin decreases. The protein efficiency values were more than doubled by rumensin feeding with 25% SBM (Table 2). The response was a 50% increase in Trial 2 with 50% SBM and no response at that level of SBM in Trial 1. Evidently the protein requirement was met at the higher level (50% SBM) in Trial 1 but not in 2. Much of the response to rumensin on high fiber diets for growing cattle appears to be due to a protein sparing effect. This effect is maximized when natural protein is fed below the requirement if urea is supplied to meet microorganism needs.

Table 1. Response of growing calves to protein level, rumensin and protein heating.

Treatment			Trial I		Trial II	
	Rumensin[a]	Protein level	Daily gain, lb	Feed/gain	Daily gain	Feed/gain
			lb (kg)		lb (kg)	
Urea	–	0	1.70 (.77)	7.25	1.32 (.60)	9.09
	+	0	1.69 (.77)	7.16	1.30 (.60)	9.22
SBM	–	25	1.69 (.77)	7.51	1.38 (.63)	8.93
	–	50	2.14 (.97)	5.90	1.52 (.69)	7.88
	+	25	1.92 (.87)	6.42	1.46 (.66)	8.31
	+	50	1.96 (.89)	6.28	1.50 (.68)	8.08
HSBM	–	25	1.76 (.80)	7.05	1.38 (.63)	8.96
	–	50	2.02 (.92)	6.25	1.48 (.67)	8.40
	+	25	1.79 (.81)	6.62	1.46 (.66)	8.40
	+	50	1.91 (.87)	6.85	1.43 (.65)	8.67

[a]200 mg/hd/day.
[b]Percent of supplemental protein equivalent from natural protein.

Table 2. Level of protein and rumensin on protein efficiency.[a]

	Protein level[c]		
Rumensin[b]	25	50	Avg.
–	.33	.89	.61
+	.75	.63	.69
Avg.	.54	.76	

[a]Gain above urea conttrol ÷ protein fed above urea control.
[b]200 mg/hd/day.
[c]Percent of supplemental protein equivalent from natural protein.

Effect of Rumensin on Fiber Utilization

Calf Growth Trial 1

Trial 1 was conducted to evaluate the effect of rumensin and protein levels for growing steers fed two qualities of corn stalks. One hundred and forty-four steers averaging 210 kg were randomly allotted to six rations (eight animals per pen and three pens per treatment ration).

Early harvest corn stalklage was harvested at the time of high moisture grain harvest (74% DM) and stored in silopress bags. Late harvest corn stalklage was harvested three weeks later and stored in silopress bags. A soybean meal based supplement was used to meet the specific protein requirements for the treatments and was fed at 20% of the ration dry matter. Rumensin was added to the supplements at the levels of 0 or 30 g per ton of ration.

Steer Metabolism Trials

The effects of corn stalk quality

Table 3. Stalk quality and rumensin at two protein levels on calf performance.[a]

Item	Early harvested stalklage (EH)								Late harvested stalklage (LH)			
	10%Protein		10% Protein		11.5% Protein		11.5% Protein		11.5% Protein		11.5% Protein	
Rumensin level, gm/ton	0		30 (.76)[b]		0		30 (174)[b]		0		30 (128)[b]	
Initial weight, lb(kg)	461	(209)[c]	436	(189)	434	(197)	457	(207)	460	(209)	406	(209)
Daily feed (DM), lb (kg)	12.1	(5.5)	11.7	(5.3)	11.9	(5.4)	11.6	(5.3)	9.0	(4.1)	8.5	(3.9)
Daily gain, lb (kg)	.52	(.24)	.63	(.29)	.70	(.32)	.58	(.26)	.28	(.13)	.39	(.18)
Feed/gain	23.2		18.6		17.0		20.0		32.1		21.8	

[a]3 pens of 8 calves per treatment.
[b]mg/hd/day.
[c]Value in parenthesis is in kilograms, the other value is in pounds.

and rumensin on dry matter digestibility, fiber digestibility and rumen rate parameters were studied. The rate parameters evaluated were cellulose disappearance from a dacron bag, liquid and particulate matter disappearance from the rumen as measured by polyethylene glycol (PEG) and chromium mordanted fiber, respectively.

Four ruminally fistulated crossbred steers were used in a 4 × 4 Latin square design. Rations consisted of early harvest stalklage or late harvest stalks with rumensin at 0 or 30 g/ton. The early harvest stalklage was similar to that which was used in growth Trial 1. The late harvest stalks were harvested dry and stored in stacks. Stalks were ground in a tub grinder before feeding and were fed with the same supplements as in treatments 5 and 6 of growth Trial 1. The supplements were fed at 20% of the ration dry matter.

In a second trial, the effects of four rumensin levels on digestibility and rumen rate parameters were studied when cattle were fed late harvested corn stalks. Rumensin was fed at 0, 5, 15 and 30 g per ton of ration. The stalks were similar to those in metabolism Trial 1. The four supplements differed only in the level of rumensin. The same parameters observed in Trial 1 were measured in this metabolism trial.

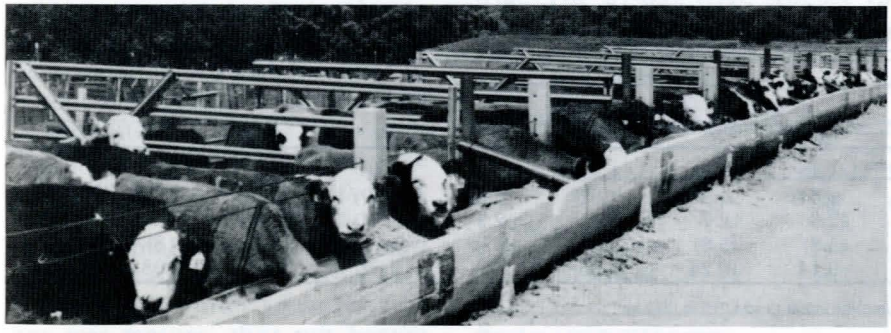
Calf Growth Trial 2

Six experimental rations consisting of 60% corn stalklage and 30% of either corn or soyhulls were fed to 144 crossbred steers with an initial average weight of 512 lb (235 kg). Superimposed upon these two rations varying in fiber content was 10% supplement containing either 0, 100 or 200 mg rumensin per head per day. Blood meal and corn gluten meal supplied half of the supplemental nitrogen, with soybean meal supplying the remaining half. Crude protein content of the rations was 11.5%. Ration protein was in excess to eliminate protein sparing as a factor.

During the trial, corn stalklage was fed *ad libitum*. Supplement and corn or soyhulls were fed at a constant level by hand on a pen basis to eliminate separation or inadequate mixing with the stalkage in the feed truck. Animals were weighed on two consecutive days at the beginning and end of the trial to reduce variation due to gut fill.

Table 4. Effect of corn stalk quality and rumensin on digestibility of corn stalks.

Item	Trial 1				Trial 2			
	Early	Harvest stalklage	Late	Harvest stalks	Late harvest stalks			
Rumensin level, gm/ton	0	30	30	30	0	5	15	30
DM digestibility (%)	65.2	62.9	53.9	52.0	52.5	55.2	55.1	55.8
Fiber digestibility (%)	64.1	61.7	60.17	57.8	60.6	63.2	61.2	63.0
Purfied cellulose disappearance (%/hr)	6.1	5.1	5.8	5.8	6.7	7.5	6.6	7.4
Liquid disappearance (%/hr)	6.7	6.3	5.5	5.8	4.8	5.2	4.5	4.9
Particulate passage (%/hr)	3.1	3.2	2.9	2.8	2.7	3.0	2.9	2.6



Calves eating stalklage suplemented with Rumensin.

Results

Growth Trial 1

Daily gains were higher for steers fed the early harvest corn stalklage than for steers fed the late harvest (Table 3). Steers fed the early harvest stalklage also had higher dry matter intakes and tended to make more efficient gains than steers fed the late harvest rations.

The cattle fed the low protein, early harvest stalklage rations had higher gains when rumensin was fed than when no rumensin was fed (Table 4). Steers fed the early harvest stalklage and 11.5% protein without rumensin tended to have higher gains than the steers on the same ration with rumensin. This difference, however, was not significant. Rumensin may be on the verge of being over fed in both rations, and there seemed to be an adverse effect on fiber utilization when protein was not limiting (11.5% protein ration).

The rumensin fed steers on the late harvest stalklage rations tended to gain faster than the steers on the same ration without rumensin. The late harvest

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Effects of Rumensin

(continued from page 15)

stalklage rations, however, were low in digestible energy as evidenced by the low gains. We feel that there may be a rumensin level problem associated with the amount of digestible energy present in the diet. The calves fed the early harvest stalklage ration consumed 36% more rumensin per day than those fed late harvest stalklage. This extra intake may have reduced performance on the early harvest stalklage ration.

Steer Metabolism Trial 1

The steers fed the early harvest stalklage showed a significant increase in dry matter and fiber digestibilities compared to late harvested stalks ration. Rumensin appeared to have no effect on dry matter or fiber digestibilities in either ration. There also was no stalk quality or rumensin effect on cellulose disappearance from a dacron bag or on liquid or particulate matter disappearance from the rumen.

Steer Metabolism Trial 2

Rumensin caused an increase in dry matter and fiber digestibility at the 5, 15 and 30 g/ton levels. Rumensin appeared to cause an overall increase in the rate of cellulose disappearance although not at the 15 g/ton level. The rate of disappearance of the liquid fraction did not differ among the four rumensin levels. The rate of particulate matter disappearance was increased at the 5 g/ton level and then decreased at the 15 and 30 g/ton levels. It appears from this trial that rumensin may affect the digestibility of high cornstalk diets, but how this may occur is still unclear. Low levels may have a positive response and higher levels a negative effect. From this trial, it also appears that rumensin may affect the ruminal rate parameters only slightly but higher levels of rumensin could be detrimental.

Calf Growth Trial 2

For both corn and soybean hull rations, daily gains increased due to the addition of 100 mg rumensin per head per day (Table 5). Addition of 200 mg rumensin resulted in lower daily gains compared to the 100 mg level. Gains resulting from 200 mg rumensin did not differ from those resulting from 0 mg rumensin.

Steers fed corn supplemented rations had greater dry matter intakes and gains compared to animals consuming soybean hull rations. Addition of 100 mg rumensin to the corn ration resulted in a significant increase in intake. A depression in intake was observed at the 200 mg level resulting in the lower daily gain observed at this rumensin level. Adding either 100 or 200 mg rumensin to the soybean hull rations caused a small but non-significant reduction in intake. It is possible that the low feed intake and gain present at the 200 mg level was due to a decreased rate of particulate matter passage and digestibility as observed in the metabolism trials.

Feed efficiency values were superior for the corn rations compared to the soybean hull rations. Addition of 100 mg rumensin to both the rations resulted in an improvement in feed efficiency, while a non-significant decrease in efficiency was observed upon addition of 200 mg rumensin to the soybean hull ration compared to the 100 mg level.

Discussion

Data indicate a rather fine balance between the digestible energy level of a ration and the optimum level of rumensin supplementation. It appears that 30g/ton was above the optimium level for best fiber digestion in growth Trial 1. This is supported by the slightly lower dry matter and fiber digestibilities in the first metabolism trial. Lower levels of rumensin appeared to stimulate fiber digestion in metabolism Trial 2 (although no depression was seen at the 30 g/ton level). The second growth trial was designed to test the effect of rumensin on fiber utilization. Soybean hulls were used as a source of very highly digestible fiber.

Clearly, 200 mg/day of rumensin was above the optimum level. The response at the 100 mg level was very good and is supported by the increased fiber digestion shown in the second metabolism trial. When corn was the source of energy, these responses were not as apparent. The corn rations were less dependent upon maximum fiber digestion and, in fact, the corn may have limited fiber digestion through negative associative effects.

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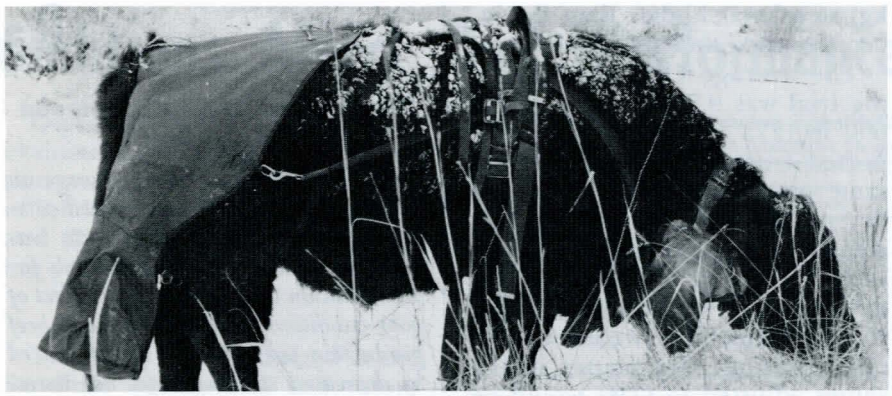
[1]Tom Trotter, Russ Olson, Bill Brown and Rick Stock are Graduate Assistants. Terry Klopfenstein is Professor (Ruminant Nutrition). Dennis Brink is Assistant Professor (Ruminant Nutrition).

Table 5. Effect of rumensin level and energy source on performance of growing steers.[a]

	Corn				Soybean hulls				Avg of corn and soybean hull rations		
	Rumensin level[b]				Rumensin level[b]				Rumensin level[b]		
	0	100	200	Avg	0	100	200	Avg	0	100	200
Daily gain, lb	1.37	1.46	1.38	1.40	1.24	1.37	1.30	1.30	1.31	1.41	1.34
(kg)	(.62)	(.66)	(.63)	(.64)	(.56)	(.62)	(.59)	(.59)	(.60)	(.64)	(.61)
Daily feed[c] lb	12.7	13.2	12.5	12.8	12.7	12.4	12.5	12.5	12.7	12.8	12.5
(kg)	(5.8)	(6.0)	(5.7)	(5.8)	(5.8)	(5.6)	(5.7)	(5.7)	(5.8)	(5.8)	(5.7)
Feed/gain[c]	9.27	9.04	9.06	9.14	10.24	9.05	9.62	9.62	9.69	9.08	9.33

[a]Fed 138 days; 8 steers per pen; 3 replications per treatment; average initial weight 516 lb (235 kg).
[b]mg/head/day.
[c]Dry matter basis.



Diet and fecal collection during the winter grazing study.

Affect on Steer Diet

Continuous Grazing

D. C. Clanton, J. T. Nichols and D. A. Yates[1]

Continuous grazing of Sandhills native forage in late August had no effect on organic matter intake (OMI) but the protein content and in vitro *organic matter digestibility (IVOMD) declined over a three week period of grazing at a normal stocking rate. The average daily OMI intake was 11.1 lb (5.0 kg) for a 600 lb (273 kg) steer. As the availability of the forage declined, the ability of the steers to selectively graze was apparently reduced. Similarly, continuous grazing of mixed prairie type range from October 30 to March 13 had no effect on intake but the crude protein (CP) content of the diet was reduced. Digestibility did not change during the winter grazing trial. The average daily OMI was 9.7 lb (4.4 kg) for a 600 lb (273 kg) steer. Steer calves gained .53 lb (.24 kg) daily during the grazing period.*

Experiments

Two experimental pastures of different vegetation types were used for two separate grazing trials. Both study areas were located within the 18 to 20 in (43 to 48 cm) precipitation zone. Stocking rates were calculated for each pasture in accordance with site potential and range condition class as suggested by Soil Conservation Service guidelines. Pastures were fully stocked according to their productive potential to approximate normal stocking rates and forage availability during late summer and winter when the forage was mature, thus not having the potential for regrowth. Pastures were not grazed during the growing season preceeding the start of the grazing trials.

Five yearling esophageal fistulated steers were used for diet and fecal collections in each trial. Diet samples were analyzed for CP and IVOMD. OMI was determined by dividing: fecal organic matter output by % indigestible diet organic matter.

Trial 1

The first trial was conducted at the Sandhills Agricultural Laboratory, 9 miles (14 km) northeast of Tryon, Nebraska. The study area was on a sands range site with soils classified as Valentine fine sands. Range condition was classified as good (58%) with predominant grass species being switchgrass, prairie sandreed, little bluestem, needleandthread and blue grama. The stocking rate was based on the commonly accepted rate of .6 AUM/A (1.48 AUM/ha) which was calculated to be .82 A (.33 ha) per animal for the 21-day trial. The 21-day trial, August 15 through September 4, 1977 was divided into three 7-day collection periods.

Trial 2

The second trial was conducted at the North Platte Station. The study area supported a mixed prairie type vegetation. The topography is rough and characterized by steep slopes and sharp breaks. The uplands are dominated by blue grama, needleandthread and threadleaf sedge, as well as numerous other species of less importance, i.e., prairie sandreed, junegrass, sand dropseed, yucca and some perennial forbs. The sharp breaks, sometimes characterized by limey parent material outcrops, support stands of little bluestem, sideoats grama, hairy grama, big bluestem, blue grama, and numerous perennial forbs. The narrow bottoms are dominated by western wheatgrass, blue grama, big bluestem, and scattered areas of snowberry. Soils are mostly silty loam. The upland range sites are predominately classified as silty and the narrow bottoms as overflow.

Five esophageal fistulated yearling steers grazed all winter with 25 steer calves in an 80 acre (32 ha) pasture. The trial lasted from October 30, 1977 through March 13, 1978. Five collection periods were conducted during the following dates: October 30 through November 5; December 1 through 7; January 2 through 8; February 3 through 9; and March 7 through 13. All animals received 1.5 lb (.68 kg) of a 40% natural protein supplement each day. Cattle were fed hay when snow prevented grazing. The fistulated steers were individually fed supplement one week before and during the collection period.

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Table 1. Change in intake, protein and digestibility of Sandhills native forage with continuous grazing (Trial 1).

Period	Organic matter intake		Crude protein	*In vitro* organic matter digestibility
	lb	(kg)	% of OM	%
1 (Aug 15-Aug 21)	9.6	(4.4)	8.9	62
2 (Aug 22-Aug 28)	12.0	(5.4)	7.7	60
3 (Aug 29-Sept 4)	11.7	(5.3)	7.3	58
S $\bar{x}$	.56	(0.25)	.21	.56

[a]Based on a 600 lb (273 kg) steer.

Continuous Grazing

(continued from page 17)

Results

Trial 1

Organic matter intake of the grazing steers increased linearly (P<.05) from period 1 through period 3 (Table 1). Average intake as a percent of body weight was 1.6%. This value agrees with dry matter intake requirements for steers at maintenance. Steers in this study just maintained their weight throughout the three week period. Continuous grazing did not reduce intake.

Daily CP content of the diet within each period was not consistently different; however, the CP decreased linearly (P<.05) from period 1 through 3 (Table 1). This decline in CP was probably due to reduced forage availability which limited the ability of the animals to select a higher quality diet. Generally, cattle graze those plants or plant parts that result in the highest quality diets.

Cattle diets decreased linearly (P<.05) in IVOMD for periods 1 through 3 (Table 1). As available forage declined, the ability of the steers to selectively graze was apparently reduced. Previous studies of quality changes in standing forage on upland-type Sandhills range from July through January of 1962 and 1963 indicate small changes in digestibility and protein content of standing forage in August would not account for all the quality changes reported here.

Trial 2

The OMI followed a quadratic relationship (P<.05) over periods (Table 2). Intake during period 2 [11.7 lb (5.3 kg) for a 600 lb (273 kg) steer] was higher than the intake for the other periods.

The average OMI throughout the trial was 9.7 lb (4.4 kg) for a 600 lb (273 kg) steer. Intake reported from earlier work on the same pasture was 4.4 lb (2.0 kg) dry matter for a 600 lb (273 kg) steer during inclement weather with snow cover, and 8.4 lb (3.8 kg) dry matter for a 600 lb (273 kg) steer during nice weather with open grazing. Dry matter intake values adjusted to OMI would be lower.

The CP in the grazed forage samples decreased (P<.05) from periods 1 through 5. The decline in CP in the diet as the winter progressed reflected the lower CP in the forage and the fact the cattle probably grazed the higher quality forage first.

There was a significant (P<.05) period effect on IVOMD (Table 2). It appeared to be a period to period difference with no specific trend such as was shown with the CP content of the diet.

Non-fistulated steer calves with an average initial weight of 422 lb (192 kg) gained .53 lb (.24 kg) daily during the winter grazing trial. Intake estimates averaged 9.7 lb (4.4 kg) based on a 600 lb (273 kg) steer for yearling fistulated steers. Steer calves gaining .53 lb (.24 kg) per day should eat approximately 10.6 lb (4.8 kg) based on a 450 lb (205 kg) steer or 9.8 lb (4.4 kg) organic matter. The estimated forage intake is consistent with the actual weight gains of the grazing steer calves.

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[1]D. C. Clanton is Professor, Animal Science (Beef). J. T. Nichols is Professor, Agronomy (Range Management). D. A. Yates is former graduate student, currently Extension Livestock Specialist, University of Wyoming, Laramie.

Table 2. Change in intake and digestibility of mixed prairie type range with continuous grazing (Table 2).

Period	Organic matter intake		Crude protein	*In vitro* organic matter digestibility
	lb	(kg)	% of OM	%
1 (Oct 30-Nov 5)	9.1	(4.2)	8.6	46
2 (Dec 1-Dec 7)	11.9	(5.3)	5.6	52
3 (Jan 2-Jan 8)	9.1	(4.2)	4.7	46
4 (Feb 3-Feb 9)	10.2	(4.6)	3.8	48
5 (Mar 7-Mar 13)	9.0	(4.1)	3.7	45
S $\bar{x}$	.35	(.16)	.17	.5

[a]Based on a 600 lb (273 kg) steer.

Range

D. J. Powell, D. C. Clanton and J. T. Nichols[1]

Yearling steers grazing range in different condition classes gained comparably when the stocking rate was adjusted to the recommended levels for the condition of the range. The effect of poor condition range is decreased beef production per acre (ha) as influenced by decreased stocking rate, not necessarily decreased quality or quantity of intake.

The digestibility of grazed Sandhills native forage during the summer was less (58.6 vs 63.4%) from a pasture (1) in high good to excellent condition (75%) than from a comparable pasture (2) in low good condition (58%), when stocked according to recommended levels. The crude protein content was 10.2 vs 9.4% for pastures 1 and 2, respectively. Both crude protein and digestibility declined during the summer grazing season. Daily organic matter intake was 10.9 and 12.2 lb (5 and 5.5 kg) based on a 600 lb (273 kg) steer in pasture 1 and 2, respectively, and declined late in the summer in both pastures.

Introduction

The Nebraska Sandhills consist of about 12.5 million acres (5.06 million ha) of rangeland. About 55% of Sandhills range is in good to excellent condition, while the remaining 45% is classified as fair and poor condition. Range condition classification provides a basis for estimating productivity, feasibility of range improvements, and suggested stocking rates.

It is generally assumed that low condition range contains a higher percentage of plants low in nutritive content and forage production. This could reduce the quality and quantity of the forage intake of grazing animals which in turn would effect their performance. The results of an eight-year study in South Dakota showed that good condition range produced the highest average daily gain, and poor condition range produced the lowest average daily gain. On excellent condition range average daily gains were intermediate.

Conditions Affect Diet, Performance

Objectives of this study were to evaluate the affect of range condition on (1) the quality and quantity of intake of grazing yearling steers and (2) the performance of grazing yearling steers.

Study Site

The study was conducted at the Sandhills Agricultural Laboratory northeast of Tryon, Nebraska. This area is within the 18 to 20 in (43 to 48 cm) precipitation zone and consists primarily of range classified as a sands range site. Soils are primarily Valentine fine sands which have drainage from adequate to excessive. Organic matter content was low, averaging about .81% and soil pH averaged about 6.8.

Steer with fecal collection harness.

Range condition and intitial stocking rates were based on procedures used by the Soil Conservation Service. Forage utilization was determined by placing wire enclosures in each pasture so that estimates could be made on the amount of forage inside and outside enclosures.

The grazing trial was from June 1, 1978 through September 22, 1978. Rainfall from June through September was 5.26 in (13.16 cm); 3.05 in (7.62 cm) below the average amount normally received during that time of year.

Table 1. *In vitro* organic matter digestibility, crude protein content, and organic matter intake of steers on Sandhills range.

Period	In vitro organic matter digestibility	Crude protein	Organic matter intake	
	%	% of OM	lb	(kg)
1. June 5-9	66.9	13.5	11.5	(5.2)
2. July 3-7	62.2	9.3	11.6	(5.3)
3. July 31-Aug 4	62.7	8.2	12.2	(5.5)
4. Aug 31-Sept 4	52.1	8.1	10.9	(5.0)
$S_{\bar{x}}$	1.4	.2	.3	(.1)

[a]Based on 600 lb (273 kg) steer.

Pasture 1 contained 150 acres (60.7 ha) in high good-excellent condition (75%). The stocking rate was calculated to be 1.09 acres (.44 ha) per animal per month. At the end of the grazing trial utilization was full (54%). The predominant grass species were: blue grama, lead plant, little bluestem, needleandthread, prairie sandreed, and switchgrass.

Pasture 2 contained 102.5 acres (41.5 ha) adjacent to pasture 1. Range condition for this pasture was low good (58%) and the stocking rate was calculated to be 1.61 acres (.65 ha) per animal per month. At the end of the grazing trial utilization was full (54%). This pasture contained the same species as pasture 1 but also included significant amounts of scribners panicum, sixweeks fescue, and western ragweed.

Data Collection

Three 2-year-old esophageal fistulated steers were used for diet sampling and fecal collection in each pasture. In addition, three non-fistulated yearling steers were used for total fecal collection in each pasture. Diet sampling and fecal collections were made during a 5-day period each month.

Ten Hereford yearling steers weighing 550 lb (250 kg) were grazed in each pasture to measure weight gains during the grazing trial. Gains were determined periodically from weights taken following an overnight removal from feed and water.

Diet and fecal samples were

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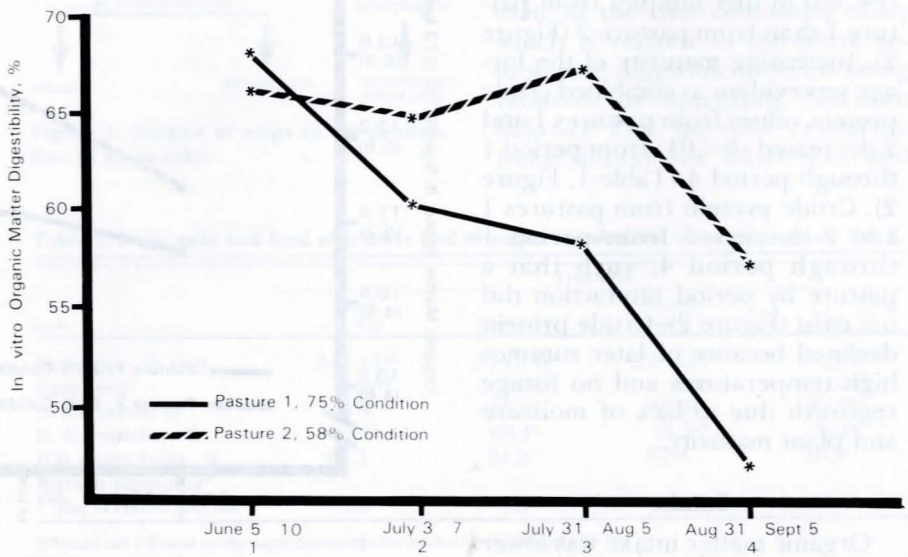

Figure 1. Digestibility of steer diets from the two pastures.

Range Conditions

(continued from page 19)

analyzed for both dry and organic matter content. Diet samples were also analyzed for crude protein (CP) and *in vitro* organic matter digestibility (IVOMD).

Organic matter intake (OMI) was determined by dividing fecal organic matter output by % indigestible diet organic matter.

Digestibility

In vitro organic matter digestibility was lower (P<.05) for pasture 1 than pasture 2 (Figure 1). Increasing maturity of forage was evident as IVOMD values were lower (P<.01) at the season's end (Table 1).

In vitro organic matter digestibility for pasture 1 decreased from period 1 through period 4; however, IVOMD for pasture 2 fluctuated (Figure 1). Because diet samples were not analyzed for botanical composition, it was impossible to determine if a species preference by cattle caused this pasture by period interaction. *In vitro* organic matter digestibility for pasture 1 probably declined because of forage regrowth due to the absence of late summer precipitation.

Crude Protein Content

Crude protein was higher (P<.05) in diet samples from pasture 1 than from pasture 2 (Figure 2). Increasing maturity of the forage was evident as combined crude protein values from pastures 1 and 2 decreased (P<.01) from period 1 through period 4 (Table 1, Figure 2). Crude protein from pastures 1 and 2 decreased from period 1 through period 4, such that a pasture by period interaction did not exist (Figure 2). Crude protein declined because of later summer high temperatures and no forage regrowth due to lack of moisture and plant maturity.

Intake

Organic matter intake was lower (P<.05) for pasture 1 than pasture 2 (Figure 3), because IVOMD was lower for pasture 1 than pasture 2 (Figure 1). The combined OMI values for both pastures remained stable from period 1 to period 2, increasing in period 3 and then declining in period 4 (Table 1, Figure 3). The change from period to period was significant (P<.05). The increase of OMI during period 3 was due to the increase of IVOMD for pasture 2 during period 3 (Figure 1). In period 4 OMI declined due to the decline of IVOMD (Table 1, Figure 1).

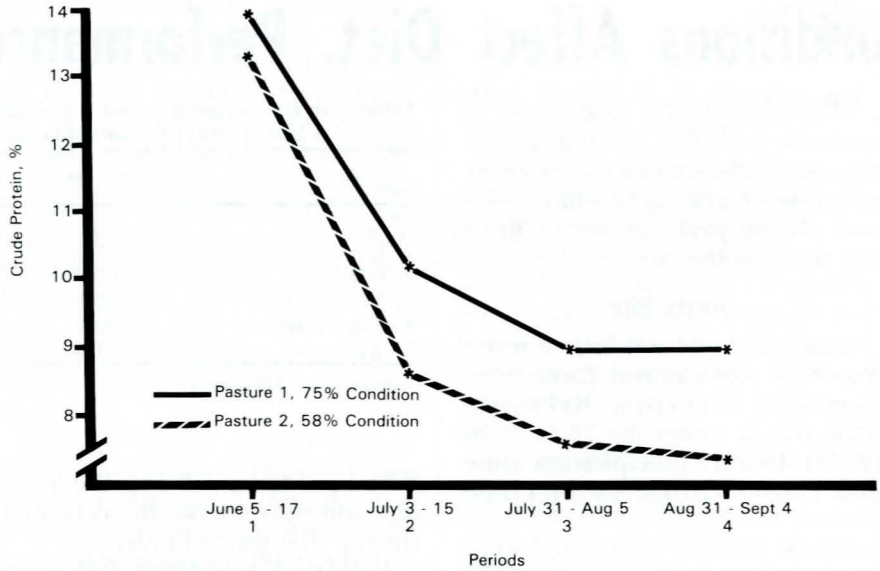

Figure 2. Crude protein of steer diets from the two pastures.

Weight Gains

Steers in pasture 1 gained 1.72 lb (.78 kg) per day, while steers in pasture 2 gained 1.58 lb (.72 kg) per day. The difference was not significant (P<.05).

Since forage quality of steer diets was similar and forage availability was not a factor the weight gains of the steers were not significantly different.

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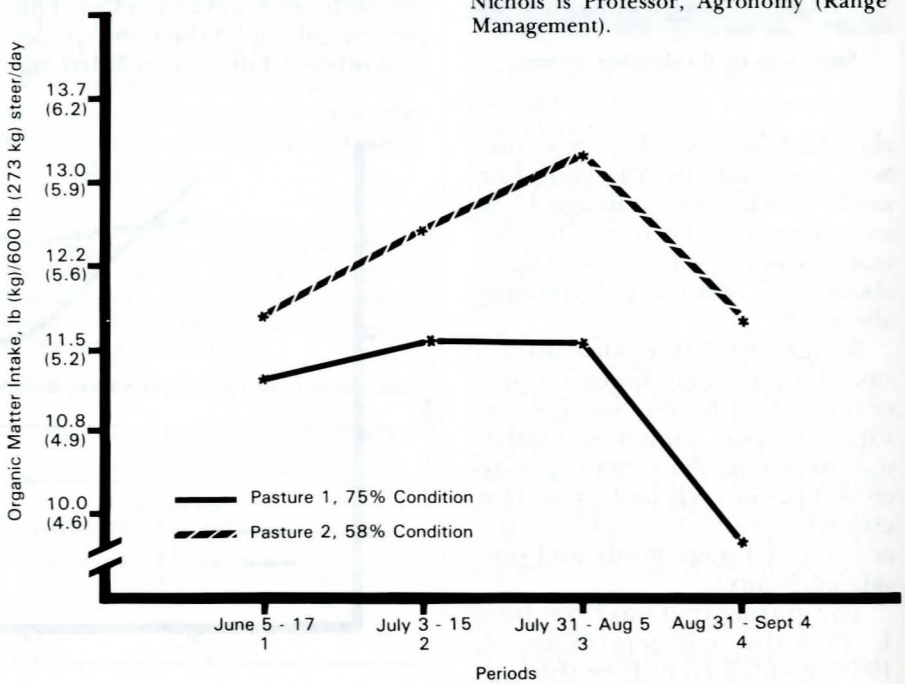

Figure 3. Intake of steers grazing the two pastures.

Individually fed calves waiting for alfalfa products.

Alfalfa Press Cake And Performance

John Merrill, Robert Britton Terry Klopfenstein and Robert Ogden[1]

Dehydrated alfalfa press cake had a lower protein digestibility but supported nitrogen balance equal to whole plant dehy. Lambs fed press cake produced gains equal to dehy and better than soybean meal or urea. Cattle performance was improved by feeding press cake alone and in combination with brown juice compared to soybean meal. The data emphasize the importance of high bypass protein in dehydrated alfalfa products for growing ruminants.

Introduction

Alfalfa processing methods are changing as a result of the need for energy conservation. One new method recently tried has been to mechanically squeeze the alfalfa plant and partially separate the proteins and xanthophylls in the juice (Figure 1). The fibrous residue, called press cake, was dehydrated for these experiments. The green juice is processed to harvest the proteins and xanthophylls (Pro-Xan). The remaining liquid is called brown juice. Our interests in this method were concerned with compositional changes in the press cake and what impact they had on nutrient utilization.

The first two experiments were conducted to test efficiency of protein utilization of the press cake in lambs relative to direct cut dehydrated alfalfa (DCD) and soybean meal (SBM). Lambs were used as laboratory animals to predict cattle performance. Alfalfa was harvested from the same field and divided into two portions. The first portion was dehydrated with a commercial drum dehydrator. The second portion had the solubles partially removed and dehydrated by the same commercial dehydrator on the same day. Apparent crude protein decreased and neutral detergent fiber increased in the press cake (Table 1). In addition, *in vitro* dry matter disappearance decreased and acid detergent insoluble nitrogen increased in the press cake. These are normal and expected changes if one removes the soluble materials from the plant.

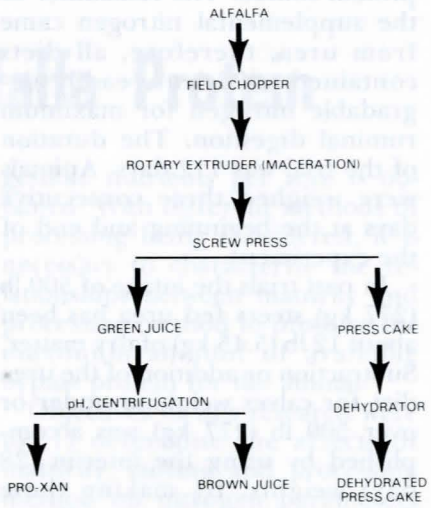

Figure 1. Outline of steps in the production of press cake.

Six wether lambs per treatment were fed diets containing either SBM, PC, DCD, or urea so that the total diet was 10.5% crude protein. Corn cobs were used as the basal roughage and direct cut dehy and press cake replaced them in the diets. Corn starch was used to equalize energy between diets.

Nitrogen digestibility in the diets containing dehy and press cake was lower than in the diet containing urea (Table 2). This decrease was probably a reflection of heating during dehydration. Nitrogen digestibility in the diet containing press cake was lower than in the diet containing dehy which is related to the more soluble and digestible proteins being removed by squeezing. Nitrogen balance and percent retention were similar for DCD, PC, and

Table 1. Composition of direct cut dehy (DCD) and press cake (PC).

Item	Dehy	Press cake
	% of DM	
Dry matter	88.6	88.1
Crude protein	25.4	21.6
Neutral detergent fiber	51.2	60.9
Acid detergent fiber	30.8	41.6
Acid detergent insoluble nitrogen	.33	.42
In vitro dry matter disappearance	66.32	60.17

Table 2. Daily gain and feed efficiency and nitrogen metabolism of lambs in trials 1 & 2.

Item	Treatment			
	Direct cut dehy	Press cake	Soybean meal	Urea
Daily gain, lb (kg)	.31 (.14)[a]	.31 (.14)[a]	.22 (.10)[b]	.17 (.08)[b]
Gain/feed	.05[a]	.05[a]	.04[a]	.03[b]
N retention, %	43.8[a]	45.2[a]	40.0[a]	24.2[b]
N digestibility, %	72.3[b]	68.4[c]	75.3[ab]	76.4[a]
DM digestibility, %	67.1	64.2	67.4	67.1
Rumen ammonia[d] mg NH_3-N/100 ml	1.5[a]	.9[a]	9.0[b]	27.7[c]

[abc]Means not followed by the same superscript are statistically significant ($P<.05$).
[d]Six hours post feeding.

Alfalfa Press Cake

(continued from page 21)

SBM, suggesting that while nitrogen digestibility was lower in diets containing PC and DCD it did not affect nitrogen balance. Rumen ammonia was highest in the diets containing urea followed by the diet with soybean meal and the two alfalfa treatments. The significantly reduced rumen ammonia in the diets containing press cake and dehy suggest the remaining proteins in these alfalfas are slowly degraded in the rumen and bypass to the rest of the gastro-intestinal tract largely intact.

Similar treatments and diets were fed in Experiment 2, a 63-day growth trial with five lambs per pen and two pens per treatment. Alfalfas were the same as those used in Experiment 1.

Lambs fed diets containing dehy and press cake gained significantly better than lambs fed diets containing soybean meal or urea (Table 2). Differences between lambs fed dehy, press cake, and soybean meal were mainly a reflection of reduced intake in the soybean meal fed group as feed efficiencies of these treatments were not different although they were all better than the urea-supplemented lambs. Unfortunately, protein was probably overfed in this experiment and utilization was not stressed as much as it should have been.

In the third experiment, four alfalfa treatments were evaluated: press cake, press cake + brown juice, press cake + brown juice + Pro-Xan, and direct cut dehy. The alfalfas were produced commercially and were different than those used in Experiments 1 and 2 (Table 3). The alfalfa treatments were compared to SBM and urea in a growth experiment utilizing sixty Angus, Hereford and Angus x Hereford calves averaging 461 lb (209 kg). The steer calves were housed in an open front barn with a gutter flush system. All animals were individually fed using electronically controlled gates.

Basal diets contained corn silage and corn cobs in a 2:1 ratio on a dry matter basis to which urea, or the protein sources were added. Diets were balanced to contain 62% TDN and 11.5% crude protein equivalence. Each protein source was fed to supply either 10, 20, 30, 40 or 50% of the supplemental nitrogen from a natural protein source. The remainder of the supplemental nitrogen came from urea, therefore, all diets contained sufficient readily degradable nitrogen for maximum ruminal digestion. The duration of the trial was 112 days. Animals were weighed three consecutive days at the beginning and end of the experiment.

In past trials the intake of 500 lb (277 kg) steers fed urea has been about 12 lb (5.45 kg) of dry matter. Subtraction or addition of the urea diet for calves weighing under or over 500 lb (277 kg) was accomplished by using the interim (28 day) weights. By making these feed intake adjustments, all animals received the same amount of feed above maintenance.

Table 4. Alfalfa products as protein sources for growing calves.

Item	Protein source: Urea	Soybean meal	Press cake	Press cake & brown juice	Press cake, brown juice & Pro-Xan	Direct cut dehy
No. of animals	10	10	10	10	10	10
Daily gain, lb(kg)	1.38 (.63)	1.46 (.66)	1.69 (.77)	1.72 (.78)	1.64 (.74)	1.57 (.71)
Daily feed, lb(kg)	11.18 (5.07)	11.19 (5.08)	12.15 (5.51)	12.12 (5.50)	11.81 (5.36)	11.88 (5.39)
Feed/gain	8.10	7.66	7.19	7.05	7.20	7.57
Efficiency (gain/prot.)	---	.427	1.477	1.640	1.366	1.271

Results

Calves fed natural protein gained faster and were more efficient than calves fed the urea control (Table 4). Among protein source, calves fed press cake and brown juice had the fastest gain followed by calves fed press cake, press cake + brown juice + Pro-Xan and dehy. Calves fed soybean meal gained slightly faster than calves fed urea. Ratios of feed to gain followed the pattern of the gain data.

Protein efficiency (Table 4) is calculated by regressing the gains of the animals fed the various levels of each protein source above the all urea supplemented group with the amount of that protein source fed per day. The slope of that regression line is an expression of the efficiency with which the animal uses that protein to deposit body tissue. Protein efficiencies of all alfalfa products were considerably higher than soybean meal. The higher protein efficiencies of the alfalfa products emphasize that this protein source is a higher bypass protein utilized with greater efficiency than a more highly rumen-degraded protein source such as soybean meal.

This experiment also demonstrates that press cake, even after partial removal of soluble protein from alfalfa, is utilized very well compared to dehy and much better than soybean meal. Brown juice appeared to improve protein efficiency which can not be explained as bypass protein in that the brown juice would not be expected to contain any. Pro-Xan decreased protein efficiency indicating that its bypass value is very low.

Table 3. Composition of alfalfas used in experiment 3.

Item, %	Press cake	Press cake & brown juice	Pro-Xan only	Direct cut dehy
	% of DM			
Dry matter	92.9	93.5	90.0	93.0
Crude protein	20.2	15.2	47.6	17.6
Acid detergent fiber	27.4	37.8	6.8	34.5
Acid detergent insoluble nitrogen	.38	.42	.18	.32

[a]Obtained from a different source than other products.

[1]John Merrill is a Graduate Assistant. Robert Britton is Associate Professor, Ruminant Biochemist. Terry Klopfenstein is Professor, Ruminant Nutrition. Robert Ogden is Assistant Professor, Alfalfa Processing.

Alfalfa is an important protein source for ruminants in Nebraska.

Heat Affects Alfalfa Protein

David Rock, Terry Klopfenstein, John Ward and Robert Britton[1]

As plants matured, percent leaf decreased and percent stem increased. Crude protein decreased, acid detergent insoluble nitrogen increased and protein degradation decreased. In vitro *ammonia release and available bypass protein decreased. Processing alfalfa increased the amount of available bypass protein in alfalfa. Heated alfalfa had greater amounts of available bypass protein than did sun-cured or freeze-dried alfalfa. Alfalfa supplemented lambs grew faster and were more efficient than urea and soybean meal supplemented controls.*

Introduction

Alfalfa quality generally decreases as the plant matures. Unfortunately, when alfalfa quality is at its highest, the yield is low. One-tenth bloom or earlier has been suggested as the maturity where the highest amount of digestible nutrients per acre is obtained. With different methods of processing being considered, it is necessary to characterize the relationships between maturity and processing method to produce the maximum amount of available bypass protein for the animal.

Objectives of this research were to: 1) determine the affects of maturity, cutting and processing method on nitrogen parameters associated with rumen protein degradation, and 2) evaluate alfalfa products processed by different methods.

Laboratory Analysis

Irrigated alfalfa was harvested at four different maturities: 1) pre-bloom (PRE), 2) 1/10 bloom, 3) 1/2 bloom and 4) full bloom (FULL) within four consecutive summer cuttings for two years (1978-79). Samples were frozen at harvest and stored for subsequent analysis.

Frozen samples were processed by one of the following methods: freeze-dried (F), sun-cured (SC), or oven-heated (H). Percentages of leaves and stems were determined and the chemical composition of the whole plant estimated from this ratio. Samples were analyzed for crude protein, acid detergent insoluble nitrogen (ADIN), ammonia release, and protein degradability.

Protein degradability was estimated with the dacron bag. Bags were 2 3/4" x 4" and constructed of dacron polyester. One gram samples were weighed into the bags. The open end of the bag was sealed and tied to a nylon drop line with nylon fishing line. The drop lines with dacron bags attached were placed into the rumen of fistulated steers for 15 hours after feeding. After an eight hour incubation, bags were removed and the nitrogen content determined. Values were expressed as nitrogen remaining and estimated ruminally available and non-available nitrogen. From this bypass N is determined. This can be converted to a crude protein basis (N x 6.25) and expressed as a percent of the total dry matter.

Percent leaf and percent stem of first and fourth cutting samples tended to be similar (Table 1). Percent leaf decreased and percent

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Table 1. Effect of cutting and maturity on percentage of leaf and stem in alfalfa.

	Cutting			
	1	2	3	4
Percent leaf	51[a]	48[ab]	45[b]	50[ab]
Percent stem	49[a]	52[ab]	55[b]	50[ab]
	Maturity			
	Prebloom	1/10 bloom	1/2 bloom	Full bloom
Percent leaf	55[a]	52[a]	47[b]	40[c]
Percent stem	45[a]	48[a]	53[b]	60[c]

[abc]Means on same line not bearing common superscript different (P<.05).

Alfalfa Protein

(continued from page 23)

stem increased as maturity advanced. Leaves generally contained 2.5 times the crude protein as did stems, had lower ADIN, higher *in vitro* ammonia release and were degraded more extensively in the rumen. This would suggest that leaves, while containing more protein, are degraded more rapidly than stems with the protein being converted to ammonia more quickly. The value of this protein source may be lower than proteins which bypass the rumen more readily. Larger amounts of ADIN in stems indicates higher apparent bypass of protein. However, this protein may not be available to the animal in the lower tract.

As maturity increased, protein of leaves, stems and the whole plant decreased. Acid detergent insoluble nitrogen increased, resulting in a smaller percentage of available protein. Available protein becomes fiber bound and in a form which the animal is unable to utilize. Protein degradability and ammonia release decreased (Table 2).

Crude protein of leaves tended to decrease in cuttings 1, 2 and 3 and increase in cutting 4. Stem nitrogen increased with subsequent cuttings (Table 2). For leaves, ADIN increased. ADIN of stems increased through the third cutting but was decreased in cutting 4 indicating that the plants of this cutting matured at a smaller plant size with less structural fiber to bind the protein present. Leaf protein was degraded to a lesser extent in cuttings 2, 3 and 4. This is directly opposite of stems. Stem protein was degraded to a greater extent as cutting number increased. Ammonia release patterns follow this same trend. Available bypass protein was increased in later cuttings for leaves and decreased for stems. This again indicates that a smaller amount of structural carbohydrate was present for protein binding in alfalfa harvested later in the summer. Whole plant values decreased with later cutting dates showing that stems exert more of an affect than do leaves.

Freeze dried values represent the composition of plant components as they are in the field (Table 2). Sun-curing tends to decrease the amount of protein in the leaves, possibly due to continued photosynthetic activity or proteolysis as the plant lays in the windrow. In general, heat in processing increased the amount of ADIN and protein remaining undegraded in the dacron bag. Following this trend, *in vitro* ammonia release value is lower in heated materials. These results show that more protein is resistant to ruminal degradation. However, some of this protein may be unavailable to the animal as indicated by increased ADIN values. For stems, a smaller amount of bypass protein is available with H material. In SC samples, the highest amount of available bypass protein was obtained. For leaves, the ADIN value is not as critical because of the high amount of protein in the leaf. Heated samples had the highest amount of available bypass protein. The amount of available bypass protein may be lower than expected for SC due to a decreased amount of protein in that material. For the whole plant, a slightly greater amount of bypass protein is available for H material with a large amount of the leaf fraction.

Animal Studies

Two lamb growth trials (individually fed) and one lamb digestion trial were conducted to evalu-

Table 2. Effect of maturity, cutting and processing on alfalfa protein.

	Maturity				Processing			Cutting			
	PRE	1/10	1/2	FULL	F	SC	H	1	2	3	4
Leaves											
Crude protein, %	26.25	24.63	22.69	21.13	24.19	22.94	23.94	23.75	23.82	22.75	24.44
ADIN[a]	5.23	6.40	6.84	7.70	5.29	3.96	10.38	5.82	6.02	6.80	7.53
Dacron bag protein[ab]	22.50	25.18	25.19	26.90	16.33	21.42	37.08	20.90	27.06	25.94	25.87
In vitro NH_3[c]	14.08	13.19	13.02	12.60	16.66	13.81	9.22	14.41	12.41	12.77	12.73
Available bypass protein[d]	4.53	4.63	4.16	4.06	2.67	2.26	6.39	3.58	5.01	4.35	4.48
Stems											
Crude protein, %	11.06	10.06	9.44	9.38	9.88	10.00	10.13	9.19	9.69	9.94	11.19
ADIN[a]	14.34	16.29	17.67	17.85	15.84	11.63	22.14	15.93	16.83	18.43	14.96
Dacron bag protein[ab]	43.35	46.40	47.78	48.40	38.93	47.88	52.88	54.08	45.31	46.41	41.12
In vitro NH_3[c]	6.57	5.93	5.30	5.26	9.47	5.27	2.55	5.44	5.81	5.95	5.85
Available bypass protein[d]	3.21	3.03	2.84	2.87	2.28	3.63	3.11	3.51	2.76	2.18	2.93
Whole plant											
Crude protein, %	19.44	17.69	15.63	14.13	16.94	16.38	17.00	16.69	16.50	16.13	17.80
ADIN[a]	9.34	11.15	12.64	13.80	10.81	7.89	16.48	10.84	11.70	13.15	11.24
Dacron bag protein[ab]	31.83	35.20	37.01	39.92	27.95	34.95	45.07	36.84	36.55	37.09	33.47
In vitro NH_3[c]	10.73	9.43	9.03	8.45	12.97	9.48	6.53	10.08	8.95	9.29	9.32
Available bypass protein[d]	4.37	4.25	3.81	3.69	2.90	4.43	4.86	4.34	4.10	3.86	3.96

[a]Percent of total N.
[b]Percent remaining.
[c]mg NH_3-M
[d]Percent of total DM.

Table 3. Lamb performance on fresh, sun-cured and heated alfalfas.

Item	Dietary treatment			
	Urea	Fresh frozen	Sun-cured	Heated
No. of animals	8	10	10	9
Daily gain, lb (kg)[b]	.13 (.061)	.20 (.090)	.18 (.083)	.22 (.098)
Feed/gain	10.7	7.9	7.5	6.1
Gain/protein[a]	–	1.43	1.14	1.40
Dry matter digestibility	71.9	75.0	76.8	75.4
Apparent nitrogen digestibility	73.3	71.7	73.0	69.3

[a]Gain above urea control divided by added natural protein intake.
[b]Urea significantly different (p<.05).

ate fresh cut, sun-cured and heated alfalfa products. Second cutting and 1/10 bloom maturity was used. In Trial 1, 40 crossbred wether lambs weighing 42 lb (19.8 kg) were allotted to 1 of 4 treatment groups: 1) urea, 2) fresh frozen alfalfa (F), 3) sun-cured alfalfa (SC), or 4) heated alfalfa (H). A digestion trial to measure dry matter and apparent N digestibilities was conducted during the last 10 days of Trial 1. In Trial 2, 40 ewe lambs weighing 67 lb (29.4 kg) were fed rations supplemented with: 1) urea, 2) soybean meal (SBM), 3) commerical dehy (D), 4) fresh frozen alfalfa (F), or 5) sun-cured alfalfa (SC). All rations were based on corn and corn silage.

A protein efficiency value has been shown to rank protein sources according to their value in rations fed to rapidly growing ruminants and is calculated with the following equation:

$$\frac{\text{(Test protein ADG) - (Urea ADG)}}{\text{(Daily test protein fed above urea control)}}$$

In Trial 1, all alfalfa groups gained faster and were more efficient than the urea controls (Table 3). No differences were observed between alfalfas. The digestibility of dry matter of the urea ration was significantly less than the other rations (Table 3). Alfalfa fiber and corn silage fiber were replaced 1 for 1 in the diet formulation. It was assumed that these forages were equal. However, the increased digestibility of alfalfa rations would indicate that alfalfa fiber was more highly digested. The apparent N digestibility of H alfalfa was below that of F and SC suggesting a small amount of heat damage and bound protein.

For Trial 2, natural protein supplemented groups gained faster and were more efficient than the urea controls (Table 4). Alfalfa produced superior gains when compared to SBM. Commercial dehy was the most efficiently utilized protein source.

Results of the animal trials correspond directly with that of the laboratory analyses. Dehydration of alfalfa causes a larger portion of available protein bypassing the rumen and moving to the lower tract. This protein is then utilized more efficiently by the animal.

[1]David Rock is a Graduate Assistant. Terry Klopfenstein is Professor, Ruminant Nutrition. John Ward is Professor, Ruminant Nutrition. Robert Britton is Associate Professor, Ruminant Biochemist.

Table 4. Effect of supplemental nitrogen source on lamb performance.

Item	Supplemental nitrogen source				
	Urea	Soybean meal	Dehydrated alfalfa	Sun-cured	Fresh Frozen
No. of animals	8	8	7	8	8
Daily gain, lb (kg)	.13 (.057)	.18 (.083)	.24 (.108)	.20 (.089)	.20 (.092)
Feed/gain[c]	21.6	10.6	7.91	10.7	11.8
Gain/protein[ade]	–	1.83	2.81	2.25	2.13

[a]Gain above urea control divided by added natural protein intake.
[b]U vs SBM, D, SC, F significant (P<.05).
[c]U vs SBM, D, SC, F significant (P<.05).
[d]SBM vs D, SC, F significant (P<.10).
[d]D vs SC, F significant (P<.10).

Ammoniated Cobs for Growing

Mark Nelson and Terry Klopfenstein[1]

Rates of fluid passage and digestion of cellulose in the rumen were not affected by ammoniation. Rate of particulate passage of ammoniated corn cob diets was faster than the unammoniated corn cob diet. Dry matter intake of lambs fed ammoniated corn cob-bypass protein diets was significantly increased by increasing levels of ammoniation or increasing levels of dietary protein. Apparent dry matter digestibility of ammoniated corn cob-bypass protein diets by lambs was decreased by increasing level of ammoniation. Digestible dry matter intake was increased by increasing dietary protein. Digestible dry matter intake was greater for the 2 and 3% ammonia (NH_3) diets than the 0 or 4% NH_3 diets (P<.05).

Introduction

Previous research has shown that sodium hydroxide (NaOH) treatment of fibrous crop residues increased *in vitro* digestibility and rate of passage. If the fiber is rapidly passed out of the rumen, digestion will not proceed to the maximum extent possible and animal performance may not be enhanced. Ammonia treatment of crop residues has also increased *in vitro* digestibility, however, ammoniation effects on rate of digestion and passage of fibrous residues have not been investigated.

Ammoniation of fibrous materials results in a feedstuff apparently containing both fiber bound and "free" nitrogen but low in actual amino acids. Supplementation of protein may, therefore, be required for growing ruminants to maximize ration digestibility and animal performance.

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Ammoniated Cobs

(continued from page 25)

Objectives of these experiments were to investigate: 1) The effect of level of ammoniation on rates of passage and cellulose digestion, dry matter intake, and digestibility of ammoniated corn cob-bypass protein diets, and 2) The effect of level of bypass protein on dry matter intake and digestibility of ammoniated corn cob-bypass protein diets.

Trial 1

Effect of level of ammonia on rate of fluid and particulate passage and rate of ruminal cellulose digestion.

Four ruminally fistulated wethers were assigned to a 4 × 4 Latin square arrangement of dietary treatments to investigate the effects of level of ammonia upon rumen rate of passage. Animals were fed 600 g dry matter per day of a diet of 90% ammoniated corn cobs (0, 2, 3 or 4% NH_3) and 10% supplement on a dry matter basis. Supplements were balanced to meet the National Research Council's recommended nutrient levels. The corn gluten meal-blood meal mixture (equal amounts of protein from each source) was considered to have twice the value of soybean meal and, therefore, comprised half of the supplemental protein. The other half of the supplemental protein was urea in the unammoniated diet and the ammonia in the ammoniated diets. Rumen contents were sampled at 4, 8, 12, 24, 72 and 96 hours after dosing with polyethylene glycol and fiber-bound chromium. Rate of cellulose digestion was determined with cellulose in dacron bags placed in the rumen and measures the effect of ammoniation on the rumen environment.

Rumen fluid rate of passage was not affected by treatment (Table 1). However, rumen particulate rate of passage was slower for the unammoniated (0% NH_3) corn cob diet than the ammoniated corn cob diets. Rate of cellulose digestion in the rumen was not affected by treatment. However, a trend for a faster rate of cellulose digestion was noted at the higher levels of ammoniation (3 and 4% NH_3).

Trial 2

Effects of level of ammoniation and level of protein supplementation on dry matter intake and digestibility of corn cob-bypass protein diets.

Twenty-four growing lambs were assigned to a 3 × 4 factorial arrangement of dietary treatments. Main effects investigated were level of ammoniation of corn cobs (0, 2, 3 or 4% of corn cob D.M.) and amount of supplemental protein from a corn gluten meal-blood meal mixture (0, 50 or 100% of supplemental protein). Dry matter intake and apparent dry matter digestibility at *ad libitum* intake (two periods) and when dry matter intake was restricted to 350 g per day (two periods) were measured. Diets were 85% corn cobs and 15% supplement on a dry matter basis. Supplements were formulated so that 0, 50 or 100% of the supplemental protein was from a 50:50 mixture (on a protein basis) of corn gluten meal and blood meal. Supplements fed with the unammoniated (0% NH_3) corn cob diets contained urea.

Results show that as either protein level or ammonia increased (Table 2), dry matter intake per unit of metabolic body size (DMI, $g/kg^{.75}$) increased. The main effect of protein level appeared to be a linear increase in dry matter intake as protein level increased. The main effect of ammonia addition was to significantly increase dry matter intake.

Apparent dry matter digestibilities of corn cob-bypass protein diets, in general, were increased with increased protein but decreased with increased ammonia

Table 2. Dry matter intake of ammoniated corn cob-bypass protein diets by lambs ($g/kg^{.75}$).

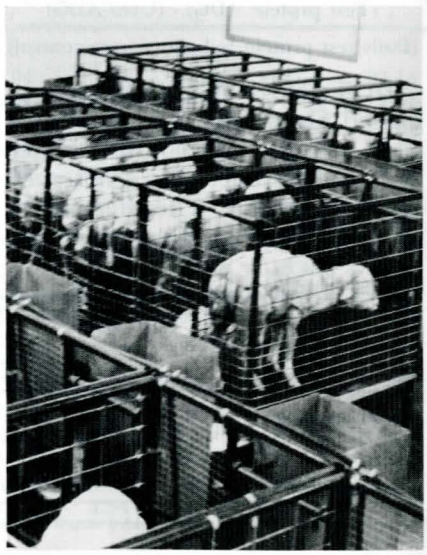
Supplement[a]	% Ammonia of corn cob D.M. 0	2	3	4	Main effect of protein
0	25.9	34.6	33.9	30.2	31.2[b]
50	33.3	40.8	40.5	35.0	37.4[c]
100	37.4	42.1	46.7	44.1	42.6[d]
Main effect of ammonia	32.2[e]	39.1[f]	40.4[f]	36.4[e,f]	

[a]Percent of supplemental protein equivalent from natural protein.
[b,c,d]Values within a column with different superscripts are significantly different (P<.05).
[e]Values within a row with different superscripts are significantly different (P<.05).

Table 1. Rumen rate parameters (% per hour).

	% Ammonia of corn cob D.M. 0	2	3	4
Fluid passage rate[a]	3.14	3.13	2.83	3.19
Particulate passage rate[b]	1.87[d]	2.47[e]	2.48[e]	2.36[e]
Cellulose digestion rate[c]	4.85	5.32	6.07	6.07

[a]Estimated from polyethylene glycol disappearance from rumen fluid.
[b]Estimated from chromium mordanted fiber disappearance from rumen particulate.
[c]Estimated from sulka floc NDF disappearance from dacron bags suspended in the rumen.
[d,e]Values within a row with different superscripts are significantly different (P<.1).



Lambs used to predict cattle performance on ammonia treated cobs.

Table 3. Dry matter digestibility of corn cob-bypass protein diets at *ad libitum* intake (%).

Supplement	% Ammonia of corn cob D.M. 0	2	3	4	Main effect of protein
0	50.4	42.3	44.8	41.1	44.7[b]
50	61.2	54.3	53.4	45	53.5[c]
100	62.3	65	61.6	55.8	61.2[d]
Main effect of ammonia	58.0[g]	53.9[f]	53.3[f]	47.3[e]	

[a]Percent of supplemental protein equivalent from natural protein.
[b,c,d]Values within a column with different superscripts are significantly different (P<.05).
[e,f,g]Values within a row with different superscripts are significantly different (P<.05).

Table 4. Apparent dry matter digestibility of corn cob-bypass protein diets when lambs were restricted to 350 g DM per day.

Supplement	% Ammonia of corn cob D.M. 0	2	3	4	Main effect of protein
0	41.7	35.5	43	41.3	40.4[b]
50	61.7	56.4	57.7	49.3	56.3[c]
100	60.2	60.4	66.7	59.2	61.6[d]
Main effect of ammonia	54.5[f]	50.8[e]	55.8[f]	49.9[e]	

[a]Percent of supplemental protein equivalent from natural protein.
[b,c,d]Values within a column with different superscripts are significantly different (P<.05).
[e,f]Values within a row with different superscripts are significantly different (P<.05).

Table 5. Digestible dry matter intake of ammoniated corn cob-bypass protein diets by lambs ($g/kg^{.75}$).

Supplement	% Ammonia of corn cob D.M. 0	2	3	4	Main effect of protein
0	13.2	15.6	15.2	12.4	14.1[b]
50	20.4	22.4	21.6	16.0	20.1[c]
100	23.2	27.1	28.9	24.8	26.0[d]
Main effect of ammonia	18.9[e]	21.7[f]	21.9[f]	17.7[e]	

[a]Percent of supplemental protein equivalent from natural protein.
[b,c,d]Values within a column with different superscripts are significantly different (P<.05).
[d,e]Values within a row with different superscripts are significantly different (P<.05).

(Tables 3 and 4). The main effect of protein level on digestibility was an increase with increased protein. However, the main effect of ammonia was that digestibility decreased as level of ammonia increased at *ad libitum* intake and at restricted intake, the 2 and 4% NH_3 diets were lower than the 0 or 3% NH_3 diets.

Digestible dry matter intakes were increased by increasing protein level and were greater (P<.05) for the 2 and 3% diets than the 0 and 4% (Table 5).

Discussion

Increasing the ruminant's dry matter intake of forage is probably a more important determinant of animal productivity than is increasing digestibility. Increasing either level of bypass protein or level of ammoniation increased dry matter intake by lambs. Whereas apparent dry matter digestibility was increased with increased bypass protein level it was decreased with increased ammoniation at *ad libitum* intakes. The implication is that ammoniation increased the rate of particulate passage out of the rumen, thereby reducing the extent of digestion.

Even though a trend appears to exist for ammoniation to increase the rate of cellulose digestion, the depressed digestibility with increased level of ammonia indicates a faster rate of passage at *ad libitum* intake thereby decreasing the amount of fiber digested in the rumen.

[1]Mark Nelson is a Graduate Assistant. Terry Klopfenstein is Professor, Ruminant Nutrition.

Corn Mixtures Improve Performance

Abe Turgeon and Dennis Brink[1]

Feeding corn particle size mixtures—50% whole—50% cracked and 50% whole—50% fine ground—improved rate and efficiency of gain compared to feeding diets of whole, cracked, or fine ground corn. Improvements in converting feed to gain in addition to reducing the expense of corn processing contributed to a lower feed cost per unit gain when the mixtures were fed.

Cattle fed 10% roughage performed better and had a lower feed cost per unit gain than cattle fed 5% or 15% roughage.

Introduction

Even though the Nebraska farmer is continuously improving corn grain yield there exists an increasing demand for this cereal grain by man as a source of food and biomaterials. The impact of ethanol production for use in gasohol may also be significant. As a result, we are faced with a challenge to increase the productive energy from corn if we are going to continue to produce choice beef economically.

The productive energy from corn can be increased by various grain processing techniques. However, these methods are very energy dependent and therefore the feasibility of their use is of great concern. Consequently, rations fed to finishing beef cattle must maximize the productive energy value from corn with minimum processing. This study was designed to investigate two factors: 1) corn particle size, and 2) roughage level, which in independent studies have been shown to affect grain utilization and performance of finishing cattle.

Experimental Procedure

One hundred twenty crossbred

(continued on next page)

Corn Mixtures

(continued from page 27)

steers weighing about 690 lb (314 kg) were individually fed *ad libitum*, utilizing electronic gates, during a 130-day feeding period. Intermediate weights were taken at 28-day intervals to monitor cattle performance. To help alleviate variation in gut fill the average weight resulting from three consecutive weighings was used as an initial weight and all final weights were based on hot carcass weight adjusted to 62% dress. Steers were implanted twice with Ralgro during the experimental period.

Three corn particle sizes and two mixtures of particle size; whole shelled corn (W), cracked corn (C) run through a roller mill equipped with a ⅜″ (9.53 mm) screen, fine ground corn (F) run through a hammer mill equipped with a ¼″ (6.35 mm) screen, a 50:50 mixture of whole and cracked corn (W-C), and a 50:50 mixture of whole and fine ground corn (W-F), were fed with alfalfa-brome hay at 5%, 10% and 15% of the ration dry matter. Therefore, 15 rations were evaluated with eight individually fed steers per ration.

Diet composition differed only in corn particle size and roughage level. Soybean meal based supplements were fed at 5% of the ration dry matter and all treatment diets were balanced for 11.5% crude protein and .35% calcium on a dry matter basis.

Table 3. Effect of corn particle size on steer performance and cost of gain.[a]

Particle size	Dry matter intake lb	(kg)	Average daily gain lb	(kg)	Feed/ gain[b]	Feed cost/ 100 lb gain	(100 kg gain)[c]
Whole	16.19	(7.36)	2.75	(1.25)	5.89	$28.90	$63.58
Cracked	17.29	(7.86)	2.97	(1.35)	5.82	30.06	66.13
Fine ground	17.12	(7.78)	2.93	(1.33)	5.89	30.51	67.12
50% Whole — 50% Cracked	16.50	(7.50)	3.06	(1.39)	5.40	27.15	59.73
50% Whole — 50% Fine ground	17.29	(7.86)	3.06	(1.39)	5.70	28.61	62.94

[a]Twenty-four individually fed steers per treatment.
[b]Dry matter intake/gain.
[c]Calculated on AGNET Beef Feedmix program (June, 1980).
Whole shelled corn — $2.30/bushel, alfalfa-brome hay-$40.00/ton, 40% crude protein supplement-$210.00/ton.
Cracking = 15.40c/bushel.
Fine grinding = 16.52c/bushel.

Producer Benefits

Animals fed the various corn particle sizes did not perform significantly different at any of the roughage levels fed. Data in Table 1 has been pooled over particle size for each roughage level. In agreement with work conducted by other researchers, dry matter intake increased as roughage level increased. Animals fed 10% roughage tended to gain the fastest and to be the most efficient when compared to animals fed the other two levels of roughage.

Cattle fed the 5% roughage level may have been slightly acidotic which may explain their lower average daily gain (ADG). Although steers fed 15% roughage consumed more dry feed they used this feed less efficiently, probably as a result of energy dilution due to added roughage.

Though no significant roughage-by-particle size interactions were detected there existed trends on particle size and more specifically on the W-C and W-F mixture treatments which may have been influenced by the level of roughage fed (Table 2).

Cattle fed the W-C mixture at 15% roughage consumed 9% more dry feed than cattle fed 5% and 10% roughage. Furthermore, cattle fed the W-C mixture at 5% and 10% roughage showed a 6% improvement in feed efficiency when compared to cattle fed 15% roughage.

Steers fed the W-F mixture at 5% roughage consumed 4.5% less dry feed than steers fed 10% and 15% roughage. As was true for steers fed the W-C mixture, steers fed the W-F mixture also required less feed for gain at the lower roughage levels. In this case, cattle fed the W-F mixture at 5% and 10% roughage showed a 7% improvement in feed efficiency when

Table 1. Effect of roughage level on steer performance and cost of gain.[a]

Roughage level %	Dry matter intake lb	(kg)	Average daily gain lb	(kg)	Feed/gain[b]	Feed cost- 100 lb gain	(100 kg gain)[c]
5	16.37	(7.44)	2.90	(1.32)	5.64	$29.27	$64.39
10	16.98	(7.72)	3.01	(1.37)	5.63	28.54	62.79
15	17.27	(7.85)	2.93	(1.33)	5.90	29.58	65.08

[a]Forty individually fed steers per treatment.
[b]Dry matter intake/gain.
[c]Calculated on AGNET Beef Feedmix program (June, 1980).
Whole shelled corn — $2.30/bushel, alfalfa-brome hay — $40.00/ton, 40% crude protein supplement—$210/ton.
Cracking = 15.40c/bushel
Fine grinding = 16.52c/bushel.

Table 2. Effect of whole-processed corn mixtures on steer performance and cost of gain.[a]

	50% Whole — 50% Cracked					50% Whole — 50% Fine ground				
Roughage level %	Dry matter intake lb	(kg)	Average daily gain lb	(kg)	Feed/ gain[b]	Feed cost/ 100 lb gain	intake (100 kg gain)[c]	Dry matter gain lb	(kg)	Average daily Feed/ lb	(kg)	Feed gain[b]	Feed Cost 100 lb gain	(100 kg gain)[c]
5	16.19	(7.36)	3.06	(1.39)	5.29	$27.14	$59.71	16.19	(7.36)	2.99	(1.36)	5.41	$27.86	$61.29
10	15.91	(7.23)	3.01	(1.37)	5.28	26.56	58.43	17.82	(8.10)	3.15	(1.43)	5.67	28.58	62.88
15	17.49	(7.95)	3.10	(1.41)	5.64	27.75	61.05	17.82	(8.10)	2.99	(1.36)	5.96	29.38	64.64

[a]Eight individually fed steers per treatment.
[b]Dry matter intake/gain.
[c]Calculated on AGNET Beef Feedmix program (June, 1980).
Whole shelled corn — $2.30/bushel, alfalfa-brome hay — $40.00/ton, 40% crude protein supplement — $210.00/ton.
Cracking = 15.40c/bushel.
Fine grinding = 16.52c/bushel.

compared to cattle fed 15% roughage.

Cattle fed the W-C and W-F mixture diets had similar rates of gain across roughage levels but appeared to be the most efficient when the lower levels of roughage were fed (5% and 10%).

Data in Table 3 represent values pooled over roughage level for each of the respective particle size treatments. Steers finished on whole shelled corn had a slower rate of gain. However, comparing feed intakes of the cattle on test indicates their low ADG to be associated with a low dry matter intake. A dustiness problem was observed with the whole corn ration at feeding time which may have influenced feed intake.

Cattle fed C and F corn rations performed essentially the same with animals fed the C diet tending to gain a little faster and to be slightly more efficient in converting feed to gain than steers fed the F corn diet.

Mixtures appear to optimize grain utilization.

Steers fed the W-F mixture gained faster and were 3.2% more efficient than cattle fed the W and F corn rations. Similarly, cattle gained faster when fed the W-C mixture diet and required 7.8% less ($P<.05$) feed per unit gain than cattle fed the W and C diets. When the average response for all other treatments was compared to the W-C mixture, the W-C mixture was 4.4% better in ADG and showed a significant improvement of 7.4% in feed efficiency.

Feed cost per unit gain for experimental rations pooled over roughage level is shown in Table 3. Lower feed costs for cattle fed the W-C and W-F mixture rations were due to improved feed efficiency with a lower processing expense.

The notable improvements in feed efficiency associated with the W-C and W-F mixture diets may be the result of better optimizing the site and extent of grain utilization, particularly starch, within the ruminants gastro-intestinal-tract.

A trial is currently underway to investigate an optimum mixture of whole and cracked corn.

[1]Abe Turgeon is a Graduate Assistant. Dennis Brink is Assistant Professor, Ruminant Nutrition.

Temperature and Feedlot Performance

Dennis Brink[1]

Performance of 400 lb (181 kg) steer calves grown to 600 lb (272 kg) on a high roughage ration and 600 lb (272 kg) steers fed a high grain ration to 1,100 lb (499 kg) was predicted with the Beef Grower program of AGNET.

Performance of finishing cattle was reduced more at warmer temperatures and less at colder temperatures than growing cattle fed a high roughage ration. Most of the difference may be attributed to differences in the heat produced in digestion of grains versus roughage and insulatory value of external fat. Although heat produced in digestion is greater for grains than roughages, additional heat during cold stress may be obtained more economically from roughages, until physical fill limits intake.

Introduction

Climatic environment can significantly influence performance and consequently the cost of producing beef. Unfortunately, cattle cannot indicate specifically when they are hot or cold (and what is hot to them may be cold to the cattle feeder). There are many factors which alter the animal's ability to withstand hot and cold environments and at least as many more factors which determine the heating or cooling power of the environment. Consequently, it is difficult to determine when the environment is influencing performance. However, researchers in Agricultural Engineering and Animal Science at UNL developed a model which is incorporated in the Beef Grower program of AGNET that predicts the performance of cattle fed at different temperatures. Results of several simulations using Beef Grower will be the basis for reviewing how and why temperature affects beef cattle performance.

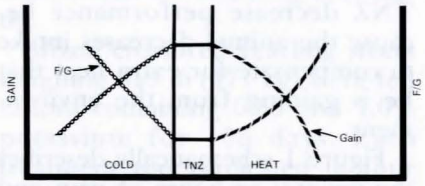


Figure 1. Schematic drawing relating gain and feed efficiency at different temperatures.

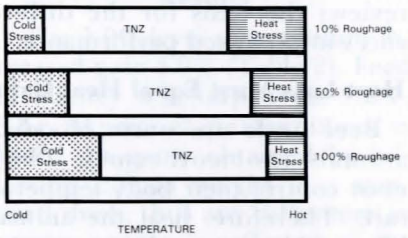


Figure 2. Roughage level and thermal stress.

Performance is Different

Summaries of the predicted performance and production cost of growing steer calves and finishing steers at 90° F (32° C), 60° F (16° C), 25° F (−4° C) and 15° F (−9° C) are shown in Tables 1 and 2. These temperatures were inserted into the Beef Grower model as constants and reflect the average mean daily air temperature (adjustments for wind, humidity, etc., were not made) for the period. Compensatory gain (increased performance at times when the temperature is more ideal) and acclimation (adjustment by the cattle to hot or cold temperatures) are not accounted for in these predictions.

Growing calves fed a high roughage ration (Table 1) appear to be affected more by the colder temperature, 15° F (−9° C). When compared to 60° F (16° C) calves

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Temperature

(continued from page 29)

grown at 15° F (−9° C) gained 30.3% less and required 40.6% more feed per pound of gain. The magnitude of the decline in performance was not as great at the warmer temperature, 90° F (32° C).

On the other hand, finishing steers fed a high grain ration (Table 2) appear to be more susceptable to warmer temperatures. Finishing steers fed at 90° F (32° C) gained 32.2% less and were about 18% less efficient in feed conversion when compared to steers fed at 60° F (16° C). But, at the colder temperature ADG was not affected and F/G was only 2.3% greater than the efficiency of steers fed at 60° F (16° C).

The remainder of the discussion reviews the basis for the differences in predicted performance.

Heat Loss Must Equal Heat Gain

Beef cattle are warm blooded animals (homeotherms). They must control their body temperature. Therefore, heat the animal loses to his surroundings must be replaced by some type of heat production. Furthermore, extra heat taken in by the animal or produced in the animal body must be lost.

When the animal is losing more heat than he is gaining (cold environment) he must work to produce heat and when the animal is gaining more heat than he is losing (hot environment) he must work to lose heat. Therefore, in regard to temperatures in the climatic environment there is a range of temperatures (often called the thermal neutral zone or comfort zone) at which the animal does not have to work to maintain his body temperature. In the thermal neutral zone (TNZ) heat loss equals heat gain with very little extra expenditure of energy by the animal. Temperatures below the TNZ decrease performance because the animal uses energy to produce enough heat to maintain body temperature. And temperatures above the TNZ decrease performance because the animal decreases intake to compensate for extra heat that he is gaining from the environment.

Figure 1 schematically describes the general response of gain and feed utilization to variation in temperatures. These general responses are reflected in the simulation data (Table 1 and 2) from the Beef Grower program. However, as indicated, there are some differences in the response of growing and finishing cattle. These differences are primarily due to the cattle having different thermal neutral zones.

What Changes the TNZ?

Two factors, heat of digestion, and insulation (amount of hair and external fat), can alter the response to temperatures. Figure 2 illustrates the relationship of roughage level and thermal stress. Heat of digestion can be a significant source of heat and is directly related to level of intake and metabolizable energy content of feed. Therefore, differences in response to temperature of finishing steers fed a high grain ration and growing steers fed a roughage ration may be explained by differences in heat of digestion.

Heat production from a pound of grain is greater than from a pound of roughage [.55 vs .40 Mcal/lb (.45kg)]. This difference is primarily due to the higher metabolizable energy content of grains. The heat produced in digestion is a major asset during cold, but a liability in heat. A finishing steer fed a high grain ration utilizes the heat of digestion to replace heat loss and is not significantly affected by cold temperatures.

Table 1. Performance and production costs of growing steer calves from 400-600 lb (181-272 kg) at different temperatures.[a]

Temperature	Daily dry matter intake[b]		Average daily gain		F/G	Feed cost ($)[c]/gain		Non feed cost ($)[d]/gain		Total cost ($)/gain	
F° (C°)	lb	(kg)	lb	(kg)		lb	(kg)	lb	(kg)	lb	(kg)
90 (32.2)	11.6	(5.3)	1.6	(.73)	7.4	.27	(.59)	.22	(.48)	.49	(1.10)
60 (15.6)	14.0	(6.4)	2.2	(1.0)	6.3	.23	(.51)	.16	(.35)	.39	(.86)
25 (-3.9)	14.0	(6.4)	2.0	(.91)	7.1	.26	(.57)	.18	(.40)	.44	(.97)
15 (-9.4)	13.7	(6.2)	1.5	(.68)	8.9	.32	(.70)	.32	(.70)	.64	(1.41)

[a]Estimated from Beef Grower (AGNET program).
[b]Ration (dry matter basis)-corn (3.25%); corn silage (87.65%); soybean meal (8.5%) limestone (.07%); dicalcium phosphate (.54%).
[c]Ration cost (dry matter basis)-$3.61/cwt ($79.42/metric ton).
[d]Non feed costs-$.22/day and interest-14%/yr.

Table 2. Performance and production costs of finishing steers from 600-1100 lb (272-499 kg) at different temperatures.

Temperature	Daily dry matter intake[b]		Average daily gain		F/G	Feed cost ($)[c]/gain		Non feed cost ($)[d]/gain		Total cost ($)/gain	
F° (C°)	lb	(kg)	lb	(kg)		lb	(kg)	lb	(kg)	lb	(kg)
90 (32.2)	14.5	(6.6)	2.1	(.95)	7.0	.32	(.70)	.18	(.40)	.50	(1.10)
60 (15.6)	18.2	(8.3)	3.0	(1.4)	6.0	.28	(.62)	.11	(.24)	.39	(.86)
25 (-3.9)	18.5	(8.4)	2.9	(1.3)	6.4	.29	(.64)	.13	(.29)	.42	(.93)
15 (-9.4)	18.3	(8.3)	3.0	(1.4)	6.2	.28	(.62)	.13	(.29)	.41	(.91)

[a]Estimated from Beef grower (AGNET program).
[b]Ration (dry matter basis)-corn (73.67%); corn silage (20.6%); soybean meal (5.07%); limestone (.67%).
[c]Ration cost (dry matter basis)-$4.61/cwt ($101.42/metric ton)
[d]Non feed costs-$.22/day and interest-14%/yr.

Canadian work indicates that feedlot steers fed (*ad libitum*) high grain rations do not need extra energy to maintain body temperature until the temperature falls below −33° F (−36° C). On the other hand growing calves fed roughage require additional energy to maintain body temperature at a much higher temperature (20-30° F) because heat of digestion is much lower on a roughage ration.

At warmer temperatures the extra heat produced by grain in the finishing ration is a liability as indicated by performance in Table 1. The finishing steer cannot use the heat of digestion for gain and decreases intake to relieve some of the heat load. Growing calves are not affected as severely by heat because roughage produces less heat of digestion.

Grain or Roughage Supplementation During Cold?

The discussion of heat of digestion and cold temperatures always brings up the question of the value of feeding high roughage rations in winter. In general, the differences in heat produced between roughage and grain is not large (.40 vs 55 Mcal, respectively) and only in cases such as high grain versus high roughage rations is the difference significant. However, sometimes the question arises whether growing calves or beef cows on high roughage rations in the winter should be fed additional roughage or grain to increase heat production. If 1 Mcal of additional heat is required it would take 2.5 lb (1.1 kg) of corn stover or 1.7 lb (.8 kg) of corn. At $20/ton ($22.40/MT) for corn stover and $2.40 per bu (25.2 kg) for corn it would cost $.025 to provide the heat using corn stover and $.08 using corn. Therefore, it is more economical to provide the extra heat from roughage; however, if large amounts of extra heat are required the animal will not be able to consume enough roughage to produce the needed heat.

[1]Dennis Brink is Assistant Professor, Ruminant Nutrition.

Potassium Improves Performance

Stanley D. Farlin and Gregory E. Schindler[1]

Finishing cattle fed rations containing 1% potassium gained 5.9% faster and were 3.2% more efficient than those fed .55% potassium.

Introduction

Increased levels of potassium are being recommended in feedlot rations. This trial was designed to determine if additional potassium is beneficial for finishing beef cattle.

Mixed crossbred yearling steers weighing 815 lb (371 kg) were fed rations containing 0.55 and 1.0% potassium for 105 days. Each treatment was replicated in four pens of 17 animals per pen.

The ration shown in Table 1 included 10% corn silage, 80% high moisture corn and 10% supplement on a dry matter basis. The ration was balanced for .45% calcium, .35% phosphorus, .25% salt and 10.5% crude protein. All cattle were implanted with Synovex-S at the beginning of the trial. Chlorotetracycline was fed intermittently at the rate of 1 g/head/day for 3 days out of every 30 days. Rumensin was added at the rate of 30 g/ton of air dry ration.

Table 1. Ration formulations (dry basis).

	Potassium level	
	0.55%	1.00%
Ration ingredients		
Corn silage	10.00	10.00
High moist. corn	80.24	80.11
Dry supp.[a]	5.00	5.00
Liquid supp.[b]	4.76	4.89
Nutrient levels		
% phosphorus	.35	.35
% calcium	.45	.45
% potassium	.55	1.00
% crude protein	10.50	10.50

[a]Dry supplement carrier for supplemental salt, phosphorus, calcium, potassium (KCl) and Rumensin (30 g/ton air dry ration).
[b]Supplemental nitrogen source.

Finishing cattle need supplemental potassium.

Results

The 1.0% level of potassium increased gain 5.9% (Table 2). Feed efficiency was improved 3.2%. The improved performance is based on gains obtained by adjusting carcass weight to a standard dress, thus any difference in carcass weight is reflected in the rate of gain. No difference occured in carcass grade between the two treatments.

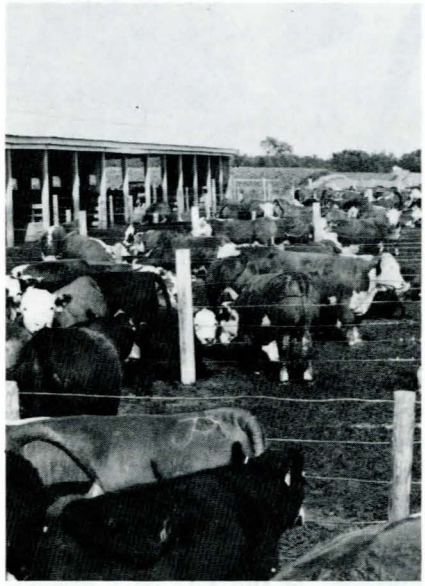
Apparently, 0.55% potassium does not permit maximum performance in finishing cattle. One percent potassium would appear to be somewhat higher than the requirement. Other research indicates levels of 0.7 to 0.8% potassium should be near the requirement for finishing beef cattle.

[1]Stanley Farlin is Associate Professor, Beef Nutrition. Greg Schindler is a Graduate Assistant.

Table 2. The effect of potassium level on finishing steers.[a]

	Potassium level			
	0.55%		1.0%	
	lb	(kg)	lb	(kg)
Initial wt.	817	(371)	816	(371)
Avg. daily gain[b]	2.38	(1.08)	2.52	(1.15)
Daily feed (DM)	18.1	(8.23)	18.5	(8.41)
Feed/gain	7.58		7.34	
Carcass weight	662	(301)	670	(305)
Quality grade	10.8		10.8	

[a]Fed for 105 days from 3/12/80 to 6/25/80.
[b]Final weight obtained by adjusting carcass weight to 62%.
[c]10 = good, 11 = high good.



Steers fed Rumensin at the Northeast Station.

Rumensin in Feedlot Rations

V. E. Krause, S. D. Farlin and D. C. Clanton[1]

Rumensin fed at 30 gm per air dry ton of mixed finishing ration improved feed conversion by 7.0%, reduced feed intake by 9.3%, and reduced gain 3.1%. Feed conversion was improved 4.1% with 20 gm rumensin, while gain and feed intake were reduced 9.4 and 11.4%. Yearling heifers fed a ration containing 49% roughage gained 14.9% faster and 21.9% more efficiently when fed 30 gm rumensin. When fed in growing and finishing programs, rumensin fed at 30 gm per ton of mixed ration improved feed efficiency 8.6%, reduced feed intake 5.7% and improved gain 3.7%. These results are based on 10 University of Nebraska trials conducted at the Mead Field Lab, North Platte Station and Northeast Station.

Introduction

Rumensin acts to improve feed efficiency through more efficient digestion of feed in the rumen. It has been widely researched and generally highly accepted by the cattle feeding industry. However, in trials conducted across the Midwest, response of cattle to rumensin has been variable. Results of experiments conducted under conditions in Nebraska may give a more accurate indication of the value of rumensin in Nebraska feedlots.

Experimental Data

Ten trials have been conducted at Nebraska experiment stations studying use of rumensin in feedlot rations (Table 1). Cattle ranged in starting weight from 431 lb (195 kg) to 828 lb (375 kg). Finishing rations were formulated to contain 10% roughage dry matter from either corn silage or alfalfa hay with the exception of trial seven which contained 20% dehydrated alfalfa and 29% ground corn cobs. The remainder of the ration was comprised of corn, protein sup-

Table 1. Summary of basic data for the 10 trials.

Trial number[a]	Location	Sex	Initial weight lb (kg)	Head/treatment Control	Head/treatment Rumensin[b]	Trial length	% Improvement[d] Daily gain	% Improvement[d] Feed intake[c,e]	% Improvement[d] Feed/gain
1	No. Platte	St	828 (375)	20	40	124	-7.4	-10.2	3.0
2	Lincoln	St	708 (321)	16	32	173	-6.8	-13.3	7.1
3	Mead	St	630 (286)	95	190	161	-7.3	-8.5	1.3
4	Mead	St	660 (299)	48	94	153	-3.0	-9.3	6.6
5	Mead	St	661 (300)	108	107	131	1.0	-5.0	6.1
6	Mead	St	653 (296)	48	48	141	4.8	-6.2	11.1
7	Mead	Hf	608 (276)	6	7	154	14.9	-11.7	21.9
8	No. Platte	Hf	431 (195)	24	47	203	1.9	-10.0	11.5
9	Northeast Station	St	605 (274)	20	40	194	5.6	2.6	2.9
10	Northeast Station	St	510 (231)	18	18	225	.4	-9.2	9.4

[a]Cattle in Trials 1-6 were fed finishing rations. Heifers in Trial 7 were individually fed a ration containing 29% corn cobs and 20% dehydrated alfalfa. Cattle in Trials 8, 9 and 10 were fed growing and finishing rations.
[b]Includes cattle receiving 20 or 30 grams of rumensin.
[c]Supplements in Trial 5 were liquid, all others were dry.
[d]Percentage difference for rumensin versus control.
[e]Finishing rations in Trials 1-6 were 10% roughage (dry basis). Growing rations in Trials 8, 9 and 10 were based on corn silage supplemented with alfalfa or soybean meal.

Table 2. Feedlot performance of cattle fed rumensin in finishing rations.

Item	Control	Rumensin 20 gm per ton	% Improvement	Rumensin 30 gm per ton	% Improvement
	lb (kg)	lb (kg)		lb (kg)	
Daily gain[a]	2.67 (1.21)	2.42 (1.10)	-9.4	2.59 (1.18)	-3.1
Feed intake[b]	20.2 (9.18)	17.9 (8.12)	-11.4	18.3 (8.34)	-9.3
Feed/gain[b]	7.72	7.40	4.1	7.19	7.0
Liver abscesses, %	28.2	-	-	29.3	-
Quality grade[c]	12.0	12.2	-	11.9	-

[a]Final weight adjusted to 62% dress based on hot carcass weight.
[b]Dry basis.
[c]12=low choice; 13=average choice.

Table 3. Feedlot performance of cattle fed rumensin in growing and finishing rations.

Item	Control	30 gm/ton rumensin	% Improvement
	lb (kg)	lb (kg)	
Daily gain[a]	2.44 (1.11)	2.53 (1.15)	3.7
Feed intake[b]	17.4 (7.89)	16.49 (7.44)	-5.7
Feed/gain[b]	7.13	6.52	8.6
Liver abscesses, %	5.3	6.3	-
Quality grade[c]	12.4	12.3	-

[a]Final weight adjusted to 62% dress based on hot carcass weight.
[b]Dry basis.
[c]12=low choice; 13=average choice.

plement, minerals and vitamins.

Growing rations fed in the first half of Trial 8, 9 and 10 were based on corn silage supplemented with alfalfa or soybean meal. Each of the trials had several treatments, but only the control 20 and 30 gm rumensin levels were used in these comparisons. Cattle in all trials except number seven were pen fed. Cattle in trial seven were individually fed.

Results

In finishing trials (1-6), feed conversion was improved 7.0% and feed intake was reduced 9.3% when 30 gm rumensin was added to the control ration (Table 2). Adjusted daily gain was reduced 3.1% by rumensin. Response to 20 gm rumensin in a finishing ration was 4.1% better feed conversion, 9.4% slower gains and 11.4% lower intake. Gains were slightly less, but since feed intake was markedly reduced, feed conversion was improved. The average improvement in feed conversion to 20 or 30 gm rumensin in high concentrate finishing rations was 5.6%. Heifers in trial seven were fed an atypical finishing ration with 49% roughage. Response to 30 gm rumensin was much greater than usually observed with a high concentrate ration. Gain was improved 14.9% and efficiency was improved 21.9%.

When growing and finishing rations were fed, feed conversion improved 8.6%, feed intake was reduced 5.7%, and daily gain was improved 3.7% (Table 3). At higher roughage levels feed intake was not reduced as much as in finishing rations and an increase in gain was observed.

All 10 trials did not show the same response to rumensin. Improvement in feed conversion varied from 1.3% to 21.9%.

Using the average of these 10 trials, return to investment was about 7 to 1 when rumensin was used.

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Acidosis, Mineral Excretion in Lambs

Affects of High Concentrate Diets

D. Harmon, G. Huntington and R. Britton[1]

As lambs are adjusted to high concentrate diets, deviations in blood and rumen acid-base balance occur that can be associated with how apruptly the diet switch takes place. Plasma calcium levels decrease as the severity of the acidosis increases. Associated with this are increased urinary calcium excretion and periods of negative calcium retention. The increased urinary mineral excretion is quantitatively unimportant in terms of balance of the animal and appears to be of short duration. The negative calcium retention has short term effects with the lighter weight, growing animals compensating with increased bone formation occuring once the animals adapt to the high concentrate diet. Deviations in magnesium and phosphorus status during adjustment to high concentrate diets were short term and do not appear detrimental to overall animal performance.

Introduction

Most research associated with the adaptation of feedlot ruminants to high concentrate diets has been conducted to better understand the microbial and biochemical changes occuring in the rumen. Associated with these ruminal changes are deviations in blood acid-base status, blood flow and amounts and route of excretion of calcium and magnesium.

Four experiments were conducted to evaluate the blood acid-base status, plasma level, and renal excretion patterns of calcium, magnesium, and phosphorus in response to varying regimens of adjusting to, and feeding of, high concentrate diets.

Table 1. Serum mineral, lactate and acid-base status of lambs abruptly switched to a 90% concentrate diet (Experiment 1).

Item	Hours after receiving 90% conc. diet	
	6	30
pH	7.44	7.20
HCO_3^- (meq/liter)	30.6	7.8
Serum calcium, mg/100 ml	10.49	8.85
Serum magnesium, mg/100 ml	2.23	2.20
Serum phosphorus, mg/100 ml	4.13	4.77
Serum lactate, mg/100 ml	14.1	99.1

First and Second Experiments

Two experiments were conducted to monitor acid-base status and serum calcium, magnesium, and phosphorus of sheep fed varying levels of dietary concentrate.

In Experiment one, three lambs weighing 73 lb (33 kg) were fed .23 lb (560 g) of mature brome hay daily for 14 days then switched to a 90% concentrate diet (*ad libitum*) for two days. Blood samples were taken via jugular puncture at 6 and 30 hours following the diet switch.

In Experiment two, six lambs weighing 66 lb (30 kg) were fed 2.86 lb (1.3 kg) alfalfa-brome hay daily for 14 days then switched to a 70% concentrate diet (ad libitum) for 3 days. Blood was sampled the last day of hay feeding, 6 hours after the diet switch and the last day of 70% concentrate feeding.

Third Experiment

Six rumen-fistulated and five intact wethers weighing 108 and 73 lb (49 and 33 kg), respectively, were used to evaluate acid-base

Table 2. Serum mineral and acid-base status of lambs abruptly switched to a 70% concentrate diet (Experiment 2).

Item	Hours after switch to 70% concentrate		
	0	6	72
pH	7.41	7.44	7.39
HCO_3^- (meq/liter)	28.9	29.1	26.4
Serum calcium, mg/100 ml	10.20	9.71	8.04
Serum magnesium, mg/100 ml	2.03	2.25	2.40
Serum phosphorus, mg/100 ml	6.61	7.47	6.28

High Concentrate Diets

(continued from page 33)

status; alkaline phosphatase activity (AP), plasma level, urinary excretion and balance of calcium, magnesium and phosphorus during stepwise adaptation to a high concentrate diet. Animals were fed pelleted alfalfa hay the first 5 days then switched to a 65% concentrate diet during days 6 through 10 and an 85% concentrate diet on days 11 through 15. Blood samples were taken via jugular catheter on days 5, 6, 10, 11 and 15 from intact wethers and days 5 through 15 from fistulated wethers. Samples on day 5 and 10 were taken before the diet switch.

Fourth Experiment

Six rumen-fistulated wethers weighing 55 lb (25 kg) were used to evaluate criteria as in the third experiment during stepwise adjustment and for 25 days of high concentrate feeding. Diets were alfalfa-brome hay for days 1 through 5, 50% concentrate for days 6 through 10, 70% concentrate for days 11 through 15 and 90% concentrate for days 16 through 40. Blood samples were taken on days 1, 3 and 5 of each feeding period. Urine and feces were composited for each-5-day feeding period. No samples were taken on days 21 through 25 or 31 through 35.

Results

Acid-base status of animals in Experiment 1 was severely affected at 30 hours as compared to 6 hours after receiving the 90% concentrate diet (Table 1). Blood pH and HCO_3^- levels were reduced and serum lactate concentration elevated. Serum calcium decreased 1.64 mg/100 ml from 6 to 30 hours on the 90% concentrate diet. Serum phosphorus increased slightly while serum magnesium did not appear to be affected.

Lambs switched to the 70% concentrate diet (Experiment 2) did not experience as severe an acid-insult with animals showing only slight decreases in blood pH and HCO_3^- by 72 hours following the diet switch (Table 2). Serum calcium was depressed 2.12 mg/100 ml at 72 hours of 70% concentrate feeding. Serum magnesium and phosphorus were not affected as a result of the 70% concentrate feeding.

Data from intact wethers (Experiment 3) showed depressed blood HCO_3^- levels on days 6 and 15 for the 65 and 85% concentrate diets, respectively (Table 3). Plasma calcium decreased about 1 mg/100 ml by day 10 then increased by day 15. Plasma phosphorus was decreased on day 6, the first day of 65% concentrate feeding while plasma magnesium decreased through day 15. Alkaline phosphatase activity was constant through day 10 then increased greater than 2-fold at day 15.

Fistulated wethers exhibited decreasing blood HCO_3^- levels with increasing time on concentrate feeding (Table 4). Plasma calcium levels decreased through days 8 and 9 then increased through day 15. Plasma magnesium and phosphorus both exhibited slight decreases but did not appear seriously affected. AP activities did not significantly differ through day 15.

Urinary magnesium excretion was not affected by the concentrate feeding but urine calcium in-

Table 3. Plasma mineral, lactate, bicarbonate and alkaline phosphatase data from non-fistulated wethers (Experiment 3).

Item	Day (% dietary concentrate) 5(0)	6(65)	9(65)	10(85)	15(85)
HCO_3^- (meq/liter)	26.91	20.24	25.75	24.63	19.91
Plasma calcium, mg/100 ml	10.61	10.59	9.79	9.64	11.38
Plasma magnesium, mg/100 ml	2.33	2.16	1.82	1.71	1.62
Plasma phosphorus, mg/100 ml	6.22	4.41	6.67	7.17	7.85
Plasma L (+) lactate, mg/100 ml	10.0	16.3	8.8	6.8	5.3
Alkaline phosphatase (IU/L)	22.13	23.26	21.86	20.83	49.97

Table 5. Blood bicarbonate, alkaline phosphatase, plasma level and percent retention of minerals for lambs at varing concentrate levels (Experiment 4).

Item	Days (% diet concentrate) 1-5(0)	6-10(50)	11-15(70)	16-20(90)	26-30(90)	36-40(90)
HCO_3^- (meq/l)	30.7	30.3	29.3	27.6	27.6	28.0
Alkaline phosphatase (IU/L)	32.3	42.9	53.3	45.5	82.8	119.4
Plasma calcium, mg/100 ml	9.90	9.92	10.02	9.76	10.24	10.66
Plasma magnesium, mg/100 ml	2.26	2.13	2.12	2.05	2.47	2.34
Plasma phosphorus, mg/100 ml	7.31	5.72	6.34	6.01	7.52	6.74
Calcium (%)[b]	17.2	10.6	11.7	−7.1	31.7	38.5
Magnesium (%)[b]	8.0	20.7	25.3	23.5	25.2	24.8
Phosphorus (%)[b]	10.5	40.7	30.1	26.3	40.0	37.2

[b]Percent of dietary intake retained by animal.

Table 4. Plasma mineral, lactate bicarbonate and alkaline phosphatase data from fistulated wethers (Experiment 3).

Item	Day (% dietary concentrate) 5(0)	6(65)	7(65)	8(65)	9(65)	10(65)	11(85)	12(85)	13(85)	14(85)	15(85)
HCO_3^- (meq/liter)	27.19	20.72	22.73	25.00	24.03	23.94	22.28	19.02	19.79	18.29	17.35
Plasma calcium, mg/100 ml	10.00	9.88	9.10	8.80	8.83	9.27	9.62	9.78	9.49	9.73	10.24
Plasma phosphorus, mg/100 ml	5.07	4.10	4.15	5.46	5.03	6.65	6.02	6.28	6.10	6.12	6.97
Plasma magnesium, mg/100 ml	2.33	2.24	2.14	2.09	2.05	1.95	1.82	1.81	1.78	1.87	2.08
Plasma L (+) lactate, mg/100 ml	16.0	14.3	12.9	12.9	13.2	9.2	9.1	5.4	5.4	4.3	5.6
Alkaline phosphatase (IU/L)	21.2	18.6	18.7	20.2	18.4	19.4	19.4	18.3	20.3	22.0	21.4

creased from .032 mg/day on the hay diet to .363 mg/day on the 85% concentrate diet. Urine phosphorus increased from .005 to .020 mg/day from the hay to the 85% concentrate diet. Magnesium and phosphorus balance was not affected by the concentrate feeding while calcium retentions were 2.02, −1.99 and 0.54 g/day for the hay, 65 and 85% concentrate diets, respectively.

Lambs in Experiment 4 suffered only a mild acid-base disturbance with plasma minerals exhibiting only mild fluctuations (Table 5). Magnesium retention was 20-25% for all periods of concentrate feeding with 30-40% of the dietary phosphorus intake being retained during the same period. Thus, the magnesium and phosphorus balance of the animals was not affected by the concentrate feeding. Calcium retentions were reduced on the 50 and 70% concentrate diets and negative for the first five days of the 90% concentrate. Alkaline phosphatase activity indicates that the rate of bone calcification was constant over the first 20 days then increased dramatically on day 26 to 30 and 36 to 40. These data agree with Experiment 3 in which the lighter weight (intact) wethers had an enhanced rate of bone calcification once adapted to the high concentrate diet.

This research demonstrates that lambs that are abruptly switched from hay to high concentrate diets (Experiment 1) show decreased serum calcium levels. Each subsequent experiment had a progressively less severe diet switch and the mineral problems were also lessened. The last experiment, which had the most gradual adaptation to high concentrate diets, showed that the animals experienced some acidosis and upset in calcium metabolism and excretion. But this derangement in mineral metabolism was of short duration and animals were back to normal shortly after being fed the highest concentrate level.

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Spaying and Implanting Growing and Finishing Heifers

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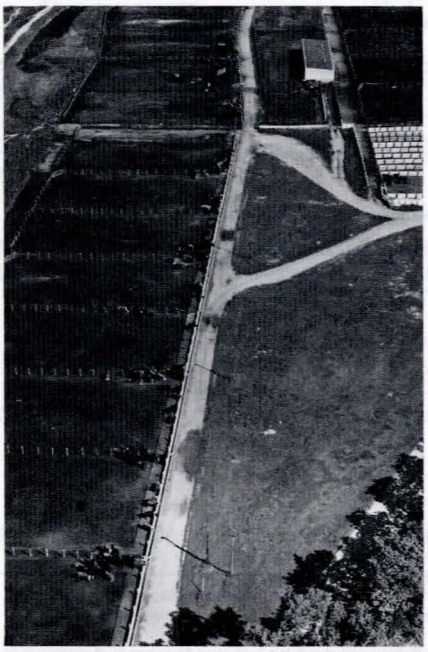
Spayed implanted heifers gained faster on grass than comparable non-implanted heifers. However, heifers implanted with Synovex-H or diethylstilbestrol (DES) during grazing had a lower rate of gain and efficiency of gain than comparable non-implanted heifers in the feedlot. Heifers implanted with Ralgro on grass maintained their gain advantage through the finishing period. Synovex-H implanted heifers gained faster than heifers implanted with Ralgro during the finishing phase. There was no significant difference in carcasses of the spayed and intact heifers. Ralgro implanted heifers on grass exhibited less udder development in the fall.

Introduction

Spaying heifers (surgically removing the ovaries) decreases management problems with grazing heifers close to bulls. Spayed heifers can be pastured or fed with steers or cow herds. A premium is often paid for guaranteed open heifers, and spaying assures open yearling heifers entering the feedlot.



Aerial of the beef unit at Mead, Nebraska.

Previous research has shown that a spayed heifer does not gain as well as the intact heifer due to lower production of growth hormones. Can gain and feed efficiency of spayed heifers be increased with growth implants, thus replacing the effect of hormones lost when the ovaries are removed? Also, what is the best implant program for growing and finishing heifers? Two trials were conducted to determine the effect of spaying and implanting both spayed and intact heifers.

Procedure

The heifers were spayed, using the high flank incision, and implanted 7-20 days before being turned to grass in the spring. Heifers were grazed on predominately crested wheatgrass (*Agropyron cristatum*, (L.) Gaertn.) pastures at the University of Nebraska High Plains Agricultural Laboratory north of Sidney. The heifers were grazed from early May to late September and then transported to the University of Nebraska Panhandle Station feedlot at Scottsbluff for finishing. Between the grazing and finishing phase the cattle were placed on a corn silage-alfalfa haylage receiving ration for 19 and 7 days for Trials 1 and 2, respectively. Initial weight for the finishing phase was taken after the feedlot adjustment period. All weights were taken after an approximate 16-hour period without feed or water. Complete carcass data was obtained on all heifers.

Trial 1

Two hundred forty-five yearling crossbred heifers, weighing about 500 pounds (227 kg), were randomly allotted to the following five treatments in May, 1978; 1) intact, non-implanted, 2) spayed, non-

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Table 1. Performance of intact, spayed and implanted spayed grazing heifers and subsequent feedlot performance (Trial 1).[a]

	Treatment for grazing period				
	Intact	Spayed			
	No implant	No implant	DES	Ralgro	Synovex
No. heifers	46	48	46	45	47
Grazing performance					
Initial wt., lb (kg)[b]	467 (212)	452 (205)	458 (207)	460 (209)	461 (209)
Fall wt., lb (kg)	691 (313)	675 (306)	710 (322)	718 (326)	707 (321)
Daily gain, lb (kg)	1.56 (.71)	1.55 (.70)	1.75 (.79)	1.79 (.81)	1.71 (.78)
No. exhibiting side effects[c]	1	2	16	3	14
Shrink, feedlot adj. period, %	4.7	5.0	4.0	4.1	4.4
Finishing performance[d]					
Finished wt., lb (kg)[e]	918 (416)	903 (410)	904 (410)	942 (427)	917 (416)
Daily gain, lb (kg)	2.04 (.93)	2.06 (.93)	1.75 (.79)	2.00 (.91)	1.91 (.87)
Feed (DM)/gain	8.85	8.96	11.37	9.82	10.47
Total performance (grazing & Finishing)					
Total gain, lb (kg)	451 (205)	451 (205)	446 (202)	482 (219)	456 (207)
Daily gain, lb (kg)	1.56 (.71)	1.56 (.71)	1.54 (.70)	1.67 (.76)	1.58 (.72)

[a]Grazed from 5-8-78 to 9-29-78 then finished to 2-22-79. (Feedlot adjustment period from 9-29-78 to 10-18-78.)
[b]Weights were taken at time of spaying and implanting.
[c]Principally, udder development—evaluated visually.
[d]One-third of the heifers in each grazing treatment were 1) not implanted, 2) implanted with Ralgro and 3) implanted with Synovex-H at the start of finishing.
[e]Finished weights were adjusted to constant 61% dressing percent.

Spaying and Implanting

(continued from page 35)

implanted, 3) spayed and implanted with DES, 4) spayed, implanted with Ralgro, and 5) spayed, implanted with Synovex-H.

The heifers were weighed when they were spayed and implanted and then again when turned on grass. The initial weights used are those taken when they were spayed and implanted.

At the start of the finishing phase, 1/3 of the heifers from each of the initial five treatments during the grazing period were either; 1) not implanted, 2) implanted with Ralgro, or 3) implanted with Synovex-H. This allowed an evaluation of reimplanting with the same implant or switching to a different implant from grazing to finishing.

Trial 2

The following year, 220 lightweight crossbred heifers, weighing approximately 395 lb (179 kg), were randomly allotted to the following grazing treatments; 1) intact, non-implanted, 2) intact, implanted with Ralgro, 3) intact, implanted with Synovex-H, 4) spayed, no implant, 5) spayed, implanted with Ralgro, or 6) spayed, implanted with Synovex-H.

Because of difficulties, the heifers were not weighed when they were spayed, consequently the initial weights were taken when the

Table 2. Performance of spayed and intact heifers when unimplanted or implanted with Ralgro and Synovex-H and subsequent feedlot performance (Trial 2).[a]

	Treatment for grazing period					
	Intact			Spayed		
	No implant	Ralgro	Synovex	No implant	Ralgro	Synovex
No. heifers	36	33	35	36	32	35
Grazing performance						
Initial wt., lb (kg)[b]	397 (180)	398 (181)	398 (181)	379 (172)	383 (174)	393 (178)
Fall wt., lb (kg)	629 (285)	649 (294)	645 (292)	613 (278)	646 (293)	656 (298)
Daily gain, lb (kg)	1.74 (.79)	1.89 (.84)	1.85 (.83)	1.75 (.79)	1.98 (.87)	1.98 (.87)
No. exhibiting side effects[c]	0	2	4	0	1	6
Shrink, feedlot adj. period, %	5.7	4.5	8.4	6.2	6.4	7.4
Finishing performance[d]						
Finished wt., lb (kg)[e]	976 (443)	999 (453)	967 (439)	975 (442)	1006 (456)	987 (447)
Daily gain, lb (kg)	2.28 (1.03)	2.26 (1.03)	2.39 (1.08)	2.39 (1.08)	2.39 (1.08)	2.25 (1.02)
Feed (DM)/gain	7.5	8.0	8.0	7.0	8.2	8.3
Total performance (grazing & finishing)						
Total gain, lb (kg)	579 (263)	601 (273)	569 (258)	596 (270)	623 (283)	594 (269)
Daily gain, lb (kg)	1.89 (.86)	1.96 (.89)	1.85 (.84)	1.94 (.88)	2.03 (.92)	1.93 (.88)

[a]Grazed from 5-1-79 to 9-11-79, finished from 9-18-79 to 3-3-80. (Feedlot adjustment period from 9-11-79 to 9-18-79.)
[b]Initial weights were taken 14 days after spaying and implanting.
[c]Principally udder development, evaluated visually.
[d]One-half of the cattle in each treatment were implanted with Ralgro and the other half with Synovex-H at initiation of finishing.
[e]Final weights were adjusted to constant 61% dressing percent.

Table 3. Effect of switching implants with spayed heifers from grazing to finishing on feedlot performance (Trial 1).

Grazing Finishing	Implant No implant Ralgro	No implant Synovex	Ralgro Ralgro	Ralgro Synovex	Synovex Snyovex	Synovex Ralgro
No. heifers	16	15	16	14	14	17
Feedlot performance						
Initial wt., lb (kg)	636 (288)	646 (293)	677 (307)	698 (317)	671 (304)	667 (303)
Final wt., lb (kg)	905 (410)	925 (420)	928 (421)	975 (442)	913 (414)	892 (405)
Daily gain, lb (kg)	2.13 (.97)	2.22 (1.01)	1.99 (.90)	2.19 (.99)	1.93 (.88)	1.79 (.81)
Feed (DM)/gain	8.3	8.3	9.4	9.2	10.8	10.7

heifers were turned to grass, 14 days after spaying. When the heifers entered the feedlot, half of the heifers within each of the initial six treatments were implanted with Ralgro and the other half were implanted with Synovex-H.

Results

Grazing Phase

Gain on grass was improved by implanting both spayed and intact heifers. Spaying did not appear to have any adverse effect on the gain of the grazing heifers as the non-implanted intact and spayed heifers gained the same in both trials (Tables 1 and 2). Implants increased gain more in the spayed than in the intact heifers during the grazing period. The implanted intact heifers had a daily gain of about .1 lb (45 gm) greater than non-implanted intact controls, while the implanted spayed heifers gained approximately .2 lb (90 gm) per day more than controls.

In the second trial the initial weight was lower for the spayed non-implanted and Ralgro implanted heifers. Initial weights were taken two weeks after the heifers were spayed and implanted, and it was possible the spayed heifers may have shrunk more than intact heifers. However, in Trial 1, heifers were weighed both at spaying and implanting and then on the average 10 days later, and there were no differences in gain during the 10-day period. It is doubtful if the spaying markedly influenced the initial weights in the second trial. There was no difference in gain due to type of implant during the grazing period. There was a noted difference in udder development of the heifers at the end of the grazing period. The heifers implanted with DES or Synovex-H had a higher incidence of udder development, as appraised visually, than non-implanted or Ralgro implanted heifers.

Finishing Phase

The effect of spaying and implanting grazing heifers was evaluated on the basis of subsequent feedlot performance. Generally, heifers not implanted on grass (which had the lowest gain on grass) had feedlot gain equal to or greater than heifers implanted on grass. The contrast was greater for feed efficiency as heifers not implanted on grass had a substantial advantage over heifers implanted on grass.

In the first trial the spayed heifers, not implanted during grazing, were 17.8% more efficient than comparable implanted heifers, and in the second trial the spayed and intact non-implanted grazing

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Table 4. Performance of finishing heifers implanted with Ralgro and Synovex-H (Trial 1).[a]

	Treatment during finishing Control	Ralgro	Synovex
No. heifers	81	80	71
Feedlot performance			
Initial wt., lb (kg)	675 (306)	663 (301)	674 (306)
Final wt., lb (kg)	908 (412)	904 (410)	940 (426)
Daily gain, lb (kg)	1.85 (.84)	1.91 (.87)	2.12 (.96)
Feed (DM)/gain	10.4	9.7	9.3
Carcass data			
Dressing percent	60.4	61.0	61.5
USDA quality grade[b]	11.8	11.8	12.1
Fat thickness, in (cm)	.48 (1.20)	.47 (1.18)	.52 (1.3)
Ribeye area, sq in (sq cm)	11.1 (72.2)	11.2 (72.8)	11.4 (74.1)
USDA yield grade	2.27	2.24	2.35

[a]Within each treatment, 80% of heifers were spayed and 20% were intact.
[b]Quality grades based on choice = 13, low choice = 12, etc.

Table 5. Comparison of feedlot performance and carcass data of intact and spayed heifers (Trial 2).[a]

	Intact	Spayed
Feedlot performance		
Initial wt., lb (kg)	609 (276)	598 (271)
Final wt., lb (kg)	980 (444)	989 (449)
Daily gain, lb (kg)	2.23 (1.01)	2.34 (1.06)
Feed (DM)/gain	8.1	7.7
Carcass data		
Dressing percent[b]	58.7	58.3
USDA quality grade[c]	12.55	13.17
Fat thickness, in (cm)	.464 (1.16)	.477 (1.19)
Ribeye area, sq in (sq cm)	11.4 (74.1)	11.3 (73.5)
USDA yield grade	2.83	2.87

[a]Within each treatment at the start of the finishing period, one-half of heifers were implanted with Ralgro and the other half with Synovex-H.
[b]Based on hot carcass wt. and live wt. one week prior to slaughter
[c]Quality grade based on choice = 13, low choice = 12, etc.

Spaying and Implanting

(continued from page 37)

heifers were 6.7% and 17.9% respectively, more efficient in the feedlot than heifers implanted on grass.

The spayed Ralgro implanted grazing heifers in Trial 1 maintained the gain advantage in the feedlot that was obtained on grass, while the total gain (spring to finish) was equal for all other heifers. In Trial 2 a similar advantage from Ralgro implantation was evident in both the spayed and intact heifers. Apparently, Ralgro implanted in grazing heifers provided a beneficial carryover effect in the finishing heifers.

In both trials there was considerable shrink during the feedlot adjustment period. The shrink did not appear to be equal for all grazing treatments in Trial 2, which influenced the total gain differences when compared to the grazing and finishing performance. The heifers implanted with Synovex-H on grass had the highest degree of shrink which lowered the total gain when compared to heifers implanted with Ralgro in the grazing phase.

It was not beneficial to switch from one type of implant during grazing to another for finishing (Table 3). Heifers that were not implanted during the grazing phase and then implanted with either Ralgro or Synovex-H gained faster and were more efficient than comparable heifers implanted on grass and then reimplanted during finishing. In both trials, Synovex-H implanted heifers gained slightly faster and were more efficient in the feedlot than Ralgro implanted or non-implanted cattle (Table 4).

Carcass data were similar for spayed and intact heifers. This is contrary to beliefs that spayed heifers will have inferior carcasses and lower dressing percentages (Table 5).

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Insecticide-impregnated eartag for horn and face fly control.

Excellent Promise

Insecticide-Impregnated Eartags

J. B. Campbell, J. I. Shugart, D. J. Boxler, D. C. Clanton and J. T. Nichols[1]

Dursban (chlorpyrifos), Rabon (stirofos), Ectrin (fenvalerate) and Burroughs-Wellcome's BW 21Z (experimental) incorporated into eartags compared favorably to forced-use of 1% Co-Ral dust bags for horn and face fly control for 4-8 weeks. During the effective time span, eartags generally provided face fly control superior to the dust bags and horn fly control was excellent with either treatment method.

Table 1. Efficacy of cattle eartags impregnated with insecticides for horn, face and stable fly control.

Trial No.	No. cattle	No. tags/ animal	Chemical (% active ingredient)	No. weeks control[a]
1	41	1	Dursban (10)	4
	13	2	"	5
	18	0	Dust bag	—
2	7	1	Rabon (14.5)	5
	8	0	Dust bag	—
3	10	1	Rabon (14.5)	6
	30	1 + dust	"	6
	10	0	Dust bag	—
4	25	1	Rabon (14.5)	8
	33	0	Dust bag	—
5	18	2	Ectrin (8)	8
	18	0	Dust bag	—
6	51	2	Dursban (10)	5
	18	0	Dust bag	—
7	24	2	BW 21Z (10)	4[b]
	24	0	Dust bag	—
8	53	1	Rabon (8.5)	7
	24	0	Dust bag	—
9	48	1	Ectrin (8.5)	4[b]
	20	0	Dust bag	—
10	24	1	BW 21Z (10)	6
	24	0	Dust bag	—

[a]Terminated when horn fly and/or face fly numbers exceeded that of cattle treated with forced-use of 1% Co-Ral dust bags.
[b]Terminated because cattle were moved to drylot.

Introduction

The insecticide-impregnated eartag concept (pieces of Shell No-Pest Strip®, which contained Vapona) was first introduced in Kansas in 1970. An eartag containing Dursban was designed in Oklahoma in 1975 for control of Gulf Coast tick which feeds in and around the ears of cattle. Following this successful trial, researchers in Texas, Oklahoma, Nebraska and other states began to evaluate several types of tags containing several different insecticides for horn and face fly control.

Although interested in the eartag for horn fly control, the prime concern at Nebraska was the effectiveness of the tags for face fly control. No other method was available that would control face flies to a non-economic level.

Procedures

Trials were conducted on cattle at the North Platte Station (NPS) or the Sandhill Agricultural Laboratory (SAL). Both fly species were present at the NPS location, but only the horn fly was present at SAL. One adjunct trial was conducted in a fly-screened feedlot facility to evaluate the tags against the stable fly, primarily a feedlot pest.

Because the trials were superimposed over ongoing animal science or range management trials, efficacy comparisons were made with control cattle managed under a system of forced-use insecticide dust bags. When fly numbers on the cattle treated with eartags surpassed numbers on cattle using dust bags, the trial was terminated. The standard for termination of a trial, superimposed over other trials, was 50 horn flies and/or 5 face flies per animal. These numbers were considered the economic threshold. Fly counts were made with the aid of field glasses. Because the fly populations were not allowed to reach natural levels, data is presented in terms of number of weeks the eartags were equal to or better than forced-use of dust bags. Forced-use consisted of placing dust bags in gateways leading to water tanks so cattle had to pass under them to obtain water.

Results

The 346 animals eartagged in 10 different trials (different eartags or insecticide formulations) had fly numbers equal to or less than cattle using forced-use of dust bags (1% Co-Ral) for about 6 weeks (range 4-8 weeks). The eartags generally provided better face fly control than did the dust bags until the efficacy of the eartags started to decline with the passage of time. Horn fly control was similar for the two methods during the time the eartags were effective.

The Dursban eartag did not appear to be as effective as the other insecticides included in the trials. Rabon provided the most acceptable fly control for the greatest length of time.

The stable fly trial (Trial 2, Table 1) is somewhat artificial, since stable flies were released into the screened pens at a rate of 5,000 per week. The overall decrease in numbers of stable flies was ca. 40% between eartag treated and untreated cattle. Although this decrease would not be considered adequate, the accumulative effect on a population under natural conditions might be more dramatic.

In summary, insecticide impregnated eartags show excellent promise as a new method of controlling pasture flies. From the standpoint of cattle management, the tags should be effective throughout the entire fly season to prevent retagging. The companies are making progress in this area by improving the insecticide release mechanism within the tag. The design of the first tags allowed considerable breakage at the shank or some pressure necrosis because the tags were too heavy. These problems have been alleviated in the design of newer tags.

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Two-year-old heifers fed Rumensin in Experiment 3.

Rumensin for Cows

D. C. Clanton and M. E. England[1]

Benefits from rumensin in winter rations for spring calving beef cows do not appear to be as great as in growing-finishing rations. In drylot, performance was similar when feed intake was reduced as rumensin was added to the ration. Rumensin addition improved the utilization of the ration so that comparable performance was achieved with less feed. In a second experiment when feed intake was maintained at the same level the addition of rumensin did not improve cow performance. On native winter range no benefit occurred from feeding rumensin in a supplement to bred yearling heifers.

Procedures

Experiment 1

One hundred cows, consisting of 52 two-year-olds, 28 three-year-olds and 20 seven-year-olds were assigned at random within age groups to four treatments of 25 cows each. The four treatments were: 0, 50, 200 and 300 mg/head/day of rumensin fed in 2 lb (.9 kg) of supplement which contained protein, minerals and vitamins to balance the diet of the cows. Following rumensin assay it

(continued on next page)

Rumensin

(continued from page 39)

was found they contained 0, 47, 181 and 279 mg/2 lb (.9 kg). The supplements were fed from November 18, 1976 until June 1, 1977.

A feeding level was established that would allow control cows to gain .50 to .75 lb (.23 to .34 kg) daily during the last trimester of pregnancy. Cows fed 50, 200 and 300 mg of rumensin daily were initially offered 95, 90 and 90%, respectively, of the feed given the control cows. Thereafter, adjustments in feeding levels were made to maintain similar body weights across all groups.

During the supplemental feeding period, in addition to 2 lb (.9 kg) of supplement which contained the daily rumensin allowance, all cows received 18 lb (8.2 kg) of chopped alfalfa and sudangrass hay the first five days of the experiment. Molasses was added to increase palatability. Thereafter, the ration was sudangrass hay, molasses, and the supplement. Corn silage was added to the ration when half of the cows in each treatment group had calved.

Table 2. The effect of rumensin on performance of cows fed in drylot (Experiment 2).

	Level of rumensin (mg/head/day)	
	0	200
Dry matter intake, lb (kg)		
Precalving, 90 days	19.6 (8.9)	19.6 (8.9)
After start of calving, 80 days	21.0 (9.5)	21.0 (9.5)
Cow weights, lb (kg)		
Initial (Dec. 5, 1977)	943 (429)	926 (421)
Gain to prepartum (Mar. 5, 1978)	66 (30)	75 (34)
Gain to postpartum (calving)	–25 (–11)	–30 (–14)
Gain, calving to pasture (May 24, 1978)	–16 (– 7)	–22 (–10)
Weaning (Sept. 21, 1978)	921 (419)	899 (409)
Cow measure, cm (change Dec. 5, 1977 to Mar. 5, 1978)		
Hip height change	–.2	–.5
Heart girth change	5.1	6.1
Reproductive performance		
Estrus 1st 21 days breeding season, %	93	85
Conception rate (AI), %	86	74
Final conception, %	93	96
Calf weights, lb (kg)		
Birth	80 (36)	84 (38)
To pasture (May 24, 1978)[a]	189 (86)	193 (88)
180-day adjusted weaning (Sept. 21, 1978)[b]	390 (177)	405 (184)

[a]Adjusted for calf age.
[b]Adjusted for sex and cow age.

The supplement was hand fed in the morning. When the supplement had been consumed the remaining ration ingredients were mixed and fed.

Cows were removed from drylot to a common pasture on June 1, 1977. At that time the supplementation was discontinued and the cows remained in one group until the calves were weaned September 8.

Cow weights and heart girth measurements (a measure of condition) were taken at the beginning of the experiment (November 18, 1976), at 28-day intervals until calving, within one day postcalving and on June 1, 1977. During the summer cow weights were taken on July 1, and September 8, when the study was terminated. Cow hip height measurements were taken at the beginning of the trial and on March 10, before calving.

Calves were weighed within 24 hours of birth and each time the cows were weighed. All calves were weaned September 8. Weights were adjusted for calf age and sex and cow age.

Artificial insemination started three weeks after onset of calving and continued until July 1. Bulls were used for 92 days following the artificial insemination. Pregnancy was determined by rectal palpation 52 days after the clean-up bulls were removed.

Table 1. The effect of rumensin on performance of cows in drylot (Experiment 1).

	Level of rumensin (mg/head/day)			
	0	50	200	300
Dry matter intake, lb (kg)				
Precalving, 112 days	14.5 (6.6)	13.9 (6.3)	13.4 (6.1)	13.4 (6.1)
After start of calving, 82 days	18.4 (8.4)	17.8 (8.1)	17.1 (7.8)	17.1 (7.8)
Cow weights, lb (kg)				
Initial (Nov. 18, 1976)	955 (434)	954 (434)	959 (436)	956 (435)
Gain to prepartum (Mar. 10, 1977)	72 (33)	65 (30)	72 (33)	56 (25)
Gain to postpartum (calving)	–45 (–20	–40 (–18)	–49 (–22)	–52 (–24)
Gain, calving to pasture (June 1, 1977)	–43 (–20)	–62 (–28)	–49 (–22)	–72 (–33)
Weaning (Sept. 8, 1977)	907 (412)	906 (412)	919 (418)	907 (412)
Cow measurements, cm				
Hip height change				
Nov. 18, 1976 to Mar. 10, 1977	.7	.6	.6	.6
Heart girth change				
Nov. 18, 1976 to Mar. 10, 1977	.6	–.2	–.6	–.7
Nov. 18, 1976 to June 1, 1977	–8.6	–9.6	–9.8	–10.1
Reproductive performance				
Estrus by June 1, %	20	20	24	17
Estrus by July 1, %	80	72	88	79
Partuition to conception, days	74	78	71	78
Conception, %	100	96	96	100
Calf weights, lb (kg)				
Birth	84 (38)	80 (36)	88 (40)	82 (32)
To pasture (June 1, 1977)[a]	222 (101)	216 (98)	231 (105)	218 (99)
Weaning, 180 day adjusted (Sept. 8, 1977)[b]	410 (186)	419 (190)	420 (191)	406 (184)

[a]Adjusted for calf age.
[b]Adjusted for sex and cow age.

Experiment 2

Sixty-four bred crossbred yearling heifers and 2-year-old cows were randomly assigned to one of two treatment groups after stratification by weight, age, and

Table 3. The effect of rumensin on performance of 2-year-old heifers on winter range (Experiment 3).

	Level of rumensin (mg/head/day)	
	0	200
Cow weights, lb (kg)		
Initial (Nov. 17, 1976)	864 (393)	862 (392)
Gain to pepartum (Feb. 9, 1977)	123 (56)	101 (46)
Gain to postpartum (calving)	–12 (–5)	–12 (–5)
Gain, calving to pasture (May 11, 1977)	–28 (–13)	–14 (–6)
Weaning (Aug. 30, 1977)	900 (409)	908 (413)
Reproductive performance		
Estrus 1st 21 days breeding season, %	82	88
Conception rate (AI), %	69	75
Final conception, %	82	88
Calf weights, lb (kg)		
Birth	57 (26)[a]	65 (30)[b]
To pasture (May 11, 1977)[c]	174 (79)	176 (80)
186-day adjusted weaning (Aug. 30, 1977)[d]	359 (163)	367 (167)

[a,b]Values in the same row with different superscripts are different (P<.05).
[c]Adjusted for calf age.
[d]Adjusted for sex.

breeding date. There were four replications of eight head on each treatment. Two of the replications were yearlings and two were 2-year-olds when the experiment started December 5, 1977.

The two treatments were 0 and 200 mg/head/day of rumensin fed in 2 lb (.9 kg) of supplement which contained protein, minerals, and vitamins to balance the diet of the cows. Assay showed rumensin levels to be 0 and 148 mg, respectively. The basal ration was low-to medium-quality grass hay fed to support no weight gain before calving. Following calving, corn silage was fed to supply 70% of the roughage dry matter with the balance from hay similar to that used prior to calving. The amount of roughage fed to each treatment group was the same. The cows were in drylot from December 5, 1977 until May 24, 1978. The general feeding procedure was the same as that used in Experiment 1.

On May 24, the cows were placed in a common pasture, supplementation was discontinued and they remained in the pasture until the calves were weaned September 21.

Cow weights were taken at the beginning of the study (December 5, 1977), at 28-day intervals until calving, within one day postcalving and May 24. During the summer, weights were taken August 1, and September 21, when the study was terminated. Cow hip height and heart girth circumference were taken at the beginning of the trial and before calving.

Calves were weighed within 24 hours of birth and each time the cows were weighed. Weights were adjusted for calf age and sex and cow age.

The cows were artificially inseminated for 30 days starting June 5. Clean-up bulls were used for another 20 days.

Experiment 3

Thirty-two bred crossbred yearling heifers were randomized to four groups of eight head each. They were randomized according to weight, and 1976 breeding dates. They grazed four similar native range pastures from November 17, 1976 until February 9, 1977 when they started calving.

Two groups were fed 2 lb (.9 kg) of supplement containing no rumensin while the other two groups received the same supplement with 200 mg rumensin per 2 lb (.92 kg) of supplement. The supplement contained 40% natural protein and minerals and vitamins. The only source of energy was the native forage. On February 9, the heifers were placed in drylot for calving. During this time they received hay and their supplement. As soon as they calved they returned to pasture and continued to receive their respective supplement plus hay and native range forage. On May 11, all cows and calves were placed in one cool season grass pasture.

Shrunk cow weights were taken at the beginning of the experiment, (November 7, 1976) at 28-day intervals until calving, within 24 hours of calving, March 23, May 11 and August 30, 1978 when the calves were weaned. The calves were weighed within 24 hours of birth and each time the cows were weighed. Weaning weights were adjusted for calf age and sex.

Reproductive data collected was similar to that collected in Experiment 2.

Results

Experiment 1

Average daily dry matter intake for the precalving and after start of calving period are shown in Table 1. There were no significant differences in cow weight change, heart girth circumference, hip weight, reproductive performance, or 180-day adjusted weaning weights when comparing the four treatments.

Experiment 2

Average daily dry matter intake for the supplemental feeding period was 19.6 lb (8.9 kg) before calving and 21.0 lb (9.5 kg) following calving for each treatment group (Table 2). There were no differences in cow weight change, heart girth circumference, hip weight, reproductive performance or 180-day adjusted weaning weights (Table 2).

Experiment 3

No significant differences occurred in weight change or reproductive performance of the heifers fed the two supplements (Table 3).

Birth weights of the calves from heifers fed rumensin was significantly (P<.05) greater than those of heifers not fed rumensin. Some of this advantage was evident in 186-day adjusted weaning weights, however, the difference was not significant.

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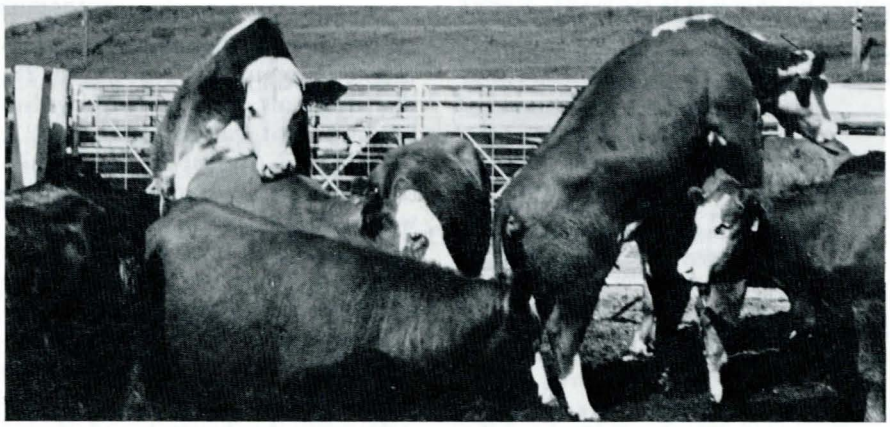

Cycling activity of cows during estrous synchronization.

Estrous Synchronization Studied

G. H. Deutscher, D. C. Clanton and L. L. Berger[1]

Estrous (heat) synchronization of yearling heifers using Syncromate B resulted in a higher conception rate (50 vs 18%) during the five days after treatment compared to a regular AI breeding program.

Trials comparing Syncro-mate B and Lutalyse showed no differences in cycling or conception rates after synchronization treatment. Pregnancy rates of yearling heifers and lactating cows from one day of breeding (mass AI) without heat detection ranged from 28 to 71%. The synchronized cows, which conceived to mass breeding, calved over a 15-day period with 85% calving in ± 4 days from the average calving date. The largest percentage of calves born on one day was 20%.

Introduction

Estrous synchronization in beef cattle is now a reality with the recent release of Lutalyse, a prostaglandin of the Upjohn Company. This product is available to beef producers as a prescription drug through licensed veterinarians. When injected intramuscularly at the recommended dosage, it acts by rapidly regressing the corpus luteum (CL) on the ovary of cycling females thus synchronizing their subsequent heat. Lutalyse has no effect on noncycling females which do not have a CL.

Syncro-mate B, a synthetic progestogen of G. D. Searle Company, is an implant which when placed subcutaneously in the ear of females for nine days, also is effective in estrous synchronization. However, this product is still experimental and not available for commercial use.

The purpose of estrous synchronization is to bring normal cycling heifers and cows into heat as a group so that breeding can be achieved in a short time. This new management tool may allow for increased use of superior sires through artificial insemination (AI) with less time and labor needed for heat detection. It may also allow for a more uniform calf crop and more concentrated breeding and calving seasons. Disadvantages are the costs of the drug plus the time, labor, and facilities needed for working the cattle.

Synchronization and Regular AI Compared

Trials were conducted in the spring of 1977 and 1978 using 92 and 75 crossbred yearling heifers, respectively, to compare a Syncro-mate B (SMB) synchronization and AI program with a regular AI program. Heifers averaged about 650 lb (295 kg) at the start of the breeding season in both years. In 1978, half of the heifers had been fed to gain .48 lb (.22 kg) per day the last 60 days before the trial while the other half gained 1.64 lb (.75 kg) per day. Sterile bulls with chin-ball markers were placed with the heifers for 21 days before each trial to determine which heifers were cycling. Heifers were then equally allotted to two breeding groups according to pre-trial gain group, weight, and cycling status.

In each trial, one group of heifers was given an implant of Syncro-mate B (SMB) subcutaneous in the ear along with a 2 cc intramuscular injection of estradiol valerate and norgestomet. Nine days later the implant was removed and the heifers were visually observed for estrus twice daily and bred by AI about 12 hours following detection of heat. The other groups of heifers was placed on a regular AI program (Reg-AI) with similar heat detection and breeding. The breeding season began on the same day for both groups. During both years, the SMB group heifers were bred by AI for about 25 days, but in 1977 a cleanup bull was also used for an additional 21 days. The Reg-AI group heifers had the same breeding season as the SMB group heifers in 1977, but in 1978 they were bred AI for 42 days. Breeding, palpation, and calving records were used to determine date of conception.

Table 1. Pregnancy rate of yearling heifers synchronized with SMB and bred on heat compared to regular AI program.[a]

Group	No. heifers	1st service conception	Pregnant in breeding season		
			5 days	25 days	44 days
		(%)	(%)	(%)	(%)
Syncro-mate B	84	55	50	76	96[b]
Regular-AI	83	67	18	71	88

[a]Results of 1977 and 1978 trials combined.
[b]Represents only 1977 results, 1978 SMB heifers were not bred after 25 days.

Table 2. Pregnancy rate of heifers and cows synchronized with Lutalyse and Syncro-mate B and mass bred.

Group	No. cows	Cycling during synchronization[a]	Pregnant in breeding season 1 day	21 days	42-47 days[b]
		(%)	(%)	(%)	(%)
Trial I—yearling heifers					
Lutalyse	31	84	30	53	80
Syncro-mate B	25	96	28	52	68
Trial II—lactating cows					
Lutalyse	29	86	66	86	100
Syncro-mate B	29	93	71	82	93

[a]Cows detected in heat after second injection of Lutalyse or after SMB implant removal and before mass AI.
[b]Total breeding season was 42 days for Trial I and 47 days for Trial II.

Lutalyse and Syncro-mate B Compared

In the spring of 1979, a two-injection Lutalyse program was compared with the Syncro-mate B program on 56 crossbred yearling heifers (Trial I) and 58 three-and four-year-old crossbred lactating cows (Trial II). All females were mass bred by AI at a predetermined time regardless of whether they were observed in heat.

The Simmental crossbred heifers were wintered as one group and averaged about 730 lb (322 kg) before the trial was initiated. Sterile bulls with chin-ball markers were placed with the heifers for 21 days before treatment to determine those heifers that were cycling. Over 90% of the heifers had cycled before the synchronization treatments. Heifers were allotted to the two breeding groups according to weight, visual body condition and cycling status.

One group received two injections of Lutalyse (5 cc per injection containing 25 mg prostaglandin $F_2\alpha$) 11 days apart and were mass artifically inseminated between 78 and 80 hours after the second injection. The other group received a subcutaneous implant of Syncro-mate B in the ear plus a 2 cc intramuscular injection of estradiol valerate and norgestomet. Nine days later the implant was removed and the heifers were mass bred by AI between 48 and 50 hours after implant removal. Both groups of heifers were mass bred to one sire on the same day. Between 16 and 21 days after mass breeding, those heifers returning to heat on the second cycle were bred by AI. Thereafter, a clean-up bull was used for 21 days. Breeding, palpation and calving records were used to determine date of conception.

The Simmental crossbred cows were in good body condition and averaged about 1150 lb (523 kg) at the start of Trial II. Sterile bulls with chin-ball markers were turned with the cows for 21 days before treatments. About 80% of the cows showed heat during this period. Cows were equally allotted to the two breeding groups according to calving date, cycling status, weight and body condition. The treatments began 53 days after the average calving date. The two breeding groups (Lutalyse and SMB) were given the same treatments as in Trial I with the addition that the calves were separated from both groups of cows for a 48-hour period immediately before mass breeding. Limited data indicate calf removal may help stimulate non-cycling cows to come into heat. Calves were fed grass hay with a clean supply of water readily available during their separation. All cows were bred AI to one sire on the same day. Two days after mass breeding, clean-up bulls of a different breed were turned with the cows for a 45-day period. Date of conception was determined by breeding, palpation and calving records.

Results and Discussion

SMB and Reg-AI — Conception results of the 1977 and 1978 trials were similar and the combined data are shown in Table 1. Percent of heifers cycling and pregnant during the first five days of the breeding season was significantly ($P<.01$) higher for the synchronized SMB group than the regular AI group (50 *vs* 18%). However, by 25 and 44 days of breeding, no significant differences were found between the groups. This indicates the SMB procedure caused the heifers that would normally cycle during a 21-day period to cycle as a group in a 5-day period.

In the 1978 trial, the high gaining heifer group had a higher percent cycling (84 *vs* 60%) before treatment than the low gaining group but this difference disappeared after 21 days of breeding. First service conception rates were similar for the two groups. Conception during the first five days of breeding and total conception rates were slightly higher for the high gaining heifers.

Lutalyse and SMB — In both Trials I and II, a high percent (90% average) of the females were observed in heat during the synchronization period with a slightly higher percent in the SMB groups (Table 2). No significant differences in pregnancy rates were found between the Lutalyse and SMB group in either trial. However, in Trial I only about 30% of the heifers conceived to the mass breeding while in Trial II about 70% of the cows conceived. This difference in conception rate may have been due to more variation in the time of cycling of the heifers after treatment and improper timing of insemination plus a lower overall fertility rate. These results should not be interpreted

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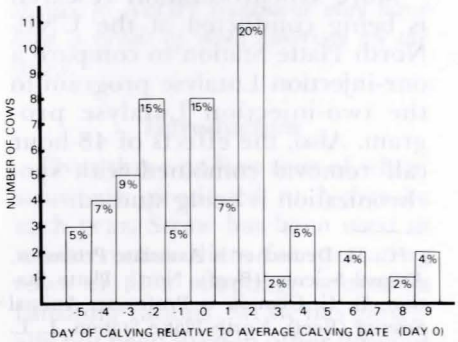

Figure 1. Distribution of calving of 55 synchronized cows conceiving from one day of mass AI breeding to the same sire.

Estrous Synchronization

(continued from page 43)

that heifers in general will have a lower conception after synchronization than cows. Results from other research studies indicate that conception of heifers should be just as high or higher than for cows.

Conception rates after synchronization treatment can vary considerably depending on the percent of females cycling, timing of insemination, quality and handling of semen, inseminator experience and general herd management. With top management most conception rates to mass breeding appear to fall between 40 and 60 percent. To obtain satisfactory results with synchronization, cycling yearling heifers, or mature, early-calving cows (at least 45 days post-calving) in gaining condition are recommended for treatment. The heifers and cows should be observed for cycling activity at least one week before treatment to determine if a high percent are cycling (4 to 5% cycling per day).

The distribution of calving which resulted from the conception from the one day of mass breeding is shown in Figure 1. Of the cows that conceived to one sire, 85% calved ± 4 days from the average calving date and all calved within 15 days. The highest percent calving in any one day was 20%. This may be surprising to beef producers who feared cows bred on the same day will calve on the same day. This variation in calving date is due to the variation in the cows' gestation lengths.

More synchronization research is being conducted at the UNL-North Platte Station to compare a one-injection Lutalyse program to the two-injection Lutalyse program. Also, the effects of 48-hour calf removal combined with synchronization is being studied.

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Table 1. Body weight and pelvic measurements of heifers treated with Ralgro.

Month relative to treatment	Body weight		Pelvic area	
	Untreated	Treated	Untreated	Treated
First year	lb (kg)	lb (kg)	sq in (sq cm)	sq in (sq cm)
0	741 (336)	747 (339)	30.4 (196)	30.4 (196)
1	774 (351)	769 (349)	30.8 (198)	31.6 (204)*
2	808 (367)	807 (366)	32.1 (207)	33.0 (213)
3	857 (389)	849 (385)	33.2 (214)	34.1 (220)*
4	870 (395)	858 (389)	34.2 (221)	35.5 (229)**
5	874 (397)	867 (393)	36.2 (233)	36.7 (237)
Second year				
0	712 (323)	709 (322)[a]	27.7 (179)	27.8 (179)[a]
1	737 (335)	754 (342)	29.8 (192)	29.5 (190)
2	753 (342)	774 (351)	31.2 (201)	31.8 (205)
3	791 (359)	816 (370)	32.7 (211)	33.4 (215)
4	797 (362)	806 (366)	35.1 (226)	35.4 (228)
5	822 (373)	833 (378)	37.3 (241)	37.8 (244)

[a]Combined data from heifers implanted once, twice or three times during gestation.
*Different (P<.05) from data for untreated heifers during same time interval.
**Different (P<.01) from data for untreated heifers during same time interval.

Ralgro Implants for Bred Heifers

R. J. Kittok, R. V. Anthony, E. F. Ellington and M. K. Nielsen[1]

Ralgro did not stimulate growth in bred heifers or consistently increase pelvic area in treated animals. The fact that several heifers aborted during the second of two trials may be of economic significance and would offset any benefits to be gained by possible increased ease in calf delivery which could result when utilizing Ralgro implants.

Introduction

A larger pelvic area of cattle has been correlated with calving ease. Heifers of large body weight tend to have large pelvic areas. Because of the above information, heifers were implanted with Ralgro in an attempt to increase the pelvic area and permit a greater ease of calf delivery.

Ralgro is a growth stimulant used in suckling calves and growing and finishing cattle. Preliminary work indicated that Ralgro-treated open heifers had lower conception rates and fertility. To avoid this decrease in reproductive efficiency, heifers were implanted at about 100 days of gestation. Monthly body weights and pelvic areas, calf birth weight, and calving ease at parturition were recorded.

During the first year (1977), 45

Table 2. Calf birth weights, calving scores and abortions in heifers treated with Ralgro.

	Birth weight	Calving score[a]	Abortion, %
First year	lb (kg)		
Untreated	64.6 (29.3)	1.47	0
Treated	68.6 (31.1)	2.20*	3.7
Hereford	64.6 (29.3)	2.00	–
Angus X Hereford	70.0 (31.7)	1.85	–
Second year			
Untreated	70.2 (31.9)	2.50	0
Treated once	66.1 (30.0)	2.23	15.0*
Treated twice	66.2 (30.0)	1.94	10.5
Treated three times	59.9 (27.2)	1.70	20.0**
Hereford	60.5 (28.7)	2.34	–
Angus X Hereford	70.7 (30.9)	1.84[b]	–

[a]Calving score based on scale of 1 to 4 (1 = no assistance, 2 = hand pull, 3 = mechanical pull, 4 = caesarean section).
[b]Different (P<.05) from data for Herefored heifers during the same time interval.
*Different (P<.05) from data for untreated heifers during same time interval.
**Different (P<.01) from data for untreated heifers during same time interval.

Table 3. Body weight and pelvic area of Angus X Hereford and Hereford heifers.

Month relative to treatment	Body weight		Pelvic area	
	Hereford	Crossbred	Hereford	Crossbred
First year	lb (kg)	lb (kg)	sq in (sq cm)	sq in (sq cm)
0	721 (327)	750 (340)**	29.0 (187)	30.8 (198)**
1	757 (343)	787 (357)**	30.3 (195)	32.1 (207)**
2	793 (360)	823 (373)**	31.4 (203)	33.7 (217)**
3	829 (376)	877 (398)**	32.4 (209)	34.8 (224)**
4	840 (381)	888 (403)**	33.8 (218)	35.9 (231)**
5	841 (382)	901 (409)**	35.3 (228)	37.5 (242)**
Second year				
0	702 (319)	717 (325)	26.8 (173)	28.8 (186)**
1	740 (336)	759 (344)	28.5 (184)	30.6 (197)**
2	752 (341)	786 (356)*	30.4 (196)	32.9 (212)**
3	792 (359)	828 (375)*	31.7 (204)	34.7 (224)**
4	785 (356)	824 (374)*	34.0 (219)	36.7 (236)**
5	803 (364)	857 (389)*	35.9 (232)	39.4 (254)**

*Different (P<.05) from data for Hereford heifers during same time interval.
*Different (P<.01) from data for Hereford heifers during same time interval.

Angus x Hereford and 10 Hereford heifers were pasture-mated to Angus bulls during a 60-day breeding season. At about 100 days of gestation, 27 heifers received a single 36 mg implant of Ralgro subcutaneous in the ear. The remaining heifers received no treatment. All heifers were pastured together and were on the same nutritional program.

The next year (1978) 57 Angus x Hereford and 23 Hereford heifers were mated to Hereford bulls during a 60-day season. These heifers received no implant (21 animals) or were implanted with Ralgro (36 mg) once (20 animals), twice (19 animals), or three times (20 animals) during gestation. The initial treatment was administered at about 100 days of gestation, and subsequent implants were given 70 and 125 days later. All heifers were pastured and fed together.

Variable Results

Compared to pregnant heifers that were not implanted, Ralgro implants did not stimulate increased body growth in pregnant heifers (Table 1). The conclusions based on the other parameters measured differed from the first to the second year of the experiment.

During the first year, implanted heifers had larger pelvic areas during the first (P<.05), third (P<.05) and fourth (P<.01) months after implanting than did the heifers not implanted. However, no advantage was observed during the fifth month following the insertion of the implant, which was about one month before calving. In contrast, during the second year no differences were detected in the pelvic areas of implanted and non-implanted heifers.

Untreated heifers had less trouble during delivery of their calves than implanted heifers (P<.05) during the first year (Table 2). However, during the second year the heifers with implants had increased calving ease (P<.10). Heifers implanted with Ralgro during the second year tended to have calves which were lighter in weight at birth.

The fact that observations from the two years differed may indicate that factors such as feed quality, weather, genetic makeup of cattle and other factors may have influenced the results.

Incidence of Abortion

During the second year, the incidence of abortion or resorption of fetuses was higher among heifers given Ralgro once (p<.05) and three times (P<.01) than among control animals (Table 2).

Genetic Differences

It was observed that Angus x Hereford heifers were larger in both body weight (P<.05) and pelvic area (P<.01) than the Hereford heifers. These differences were observed during both of the years studied (Table 3). The results of the present study may indicate the feasibility of controlling body weight and pelvic area (calving ease) with breeding programs rather than applying artificial treatments to animals.

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Ammonia Treated Wheat Straw for Cows

Dan B. Faulkner,
John K. Ward,
Terry J. Klopfenstein,
Ivan B. Rush[1]

Mature gestating beef cows responded to ammonia (NH_3) treated wheat straw with increased intake and gain when compared to untreated, sodium hydroxide (NaOH), or liquid supplement treated straw. Ammonia treatment increased the digestibility of wheat straw by 6 percent. No response was observed from NaOH or liquid supplement treatments. The lack of response to NaOH treatment may have been a result of mold observed on the straw.

Introduction

Over three million tons of wheat straw are produced in Nebraska each year. Straw has been used in maintenance diets for gestating cows or as a roughage source in finishing rations. Straw has generally not been used in other types of rations because cattle will not con-

(continued on next page)

Ammonia Treated Wheat Straw

(continued from page 45)

sume enough to meet their energy needs.

Previous work shows that mature gestating cows fed chopped wheat straw mixed with alfalfa in a 2:1 ratio gained about .5 lb (.23 kg) per day. When young cows were fed 7 lb (3.2 kg) of hay to meet their protein needs plus long straw free choice while on winter pasture, the cows did not consume enough straw to maintain body weight.

NaOH and NH_3 treatment of crop residues have been shown to improve *in vitro* dry matter disappearance (IVDMD) and dry matter intake.

When mature gestating beef cows were given a choice between untreated or liquid protein supplement treated wheat straw they consumed about five times more supplement treated straw. When the cows were given a choice between NaOH treated straw and control straw they consumed six times more NaOH treated straw. The straw was fed free choice from large round bales in bale feeders and the cows were supplemented with 7 lb (3.2 kg) of alfalfa hay daily.

NaOH treatment increased IVDMD and decreased the cell wall content of the straw. Treatment with liquid protein supplement raised the crude protein content of the straw from 3.3 to 8.6%.

Objectives of this study were to: 1) evaluate the intake and performance of cows fed untreated, NaOH treated, liquid protein supplement treated and NH_3 treated wheat straw and 2) to determine the effect of the treatments on *in vivo* and *in vitro* straw digestibility.

Procedure

After wheat harvest in July the straw was windrowed and baled into about 800 lb (362 kg) round bales. Treatment 1 consisted of untreated control straw (c).

Treatment 2 consisted of adding NaOH to the straw by spraying a NaOH solution on the straw windrow as it was picked up by the baler. The 20% NaOH (W/W) solution was applied to the straw at the rate of 4 units NaOH per 100 units dry straw. The solution was applied through an adjustable pump mounted on the tractor with a hose going to spray nozzels on the baler.

Treatment 3 consisted of spraying the straw with a liquid protein supplement (LS) (urea-molasses base, 32% crude protein) as it was baled. The pump (same as described in the previous treatment) was adjusted to apply 6% liquid supplement (DM basis).

Treatment 4 consisted of baled straw being covered with .20 mm polyethylene and injected with anhydrous ammonia (NH_3). About 3.75 units of ammonia was injected per 100 units of dry wheat straw [65 lb (29.5 kg) per ton on an air dry basis]. The edges of the polyethylene were sealed by covering with loose soil. Two 13.5 ton (12.3 metric ton) stacks were treated in this manner. The stacks were sampled by grab sampling the outside of the bales and core sampling the inside of the bales to determine the effect of location in the stack on chemical treatment of the straw. IVDMD was used as an indicator of treatment effect.

After harvest half of the bales were stored in a hay barn while the other half were stored outside and fed first. The NH_3 treated bales remained covered from mid August until the start of the trial.

The cow trial was conducted from November 27, 1979, to February 7, 1980, with 96 spring calving mature beef cows [1067 lb or (485 kg)] in drylot. There were three replications of eight cows for each treatment. The straw was fed free choice in large round bale feeders. In addition each cow received 16.3 lb (7.4 kg) of hay each Monday, Wednesday and Friday plus free choice salt and minerals. The cows were shrunk for 12 hours and weighed at the beginning of the trial and after a 5-day adjustment period at the end of the trial. All cows were fed alfalfa hay during the adjustment period to remove fill differences.

The bales were weighed before being fed, but the amount remaining at the end of the trial was visually estimated due to the difficulty of moving broken bales and contamination with manure and snow. One bale from each treatment was randomly selected and ground for a lamb intake and digestibility trial. Twenty-four crossbred wether lambs [62.7 lb (28.5 kg)] were prefed 14 days before the 10-day intake trial and the 7-day collection period to measure digestibility. The rations contained 25.3% alfalfa-bromegrass hay and 74.7% wheat straw on a dry matter basis with the same treatments and ration ingredients as in the cow trial. Intakes were determined by feeding to allow 10-15% weighback each day and the metabolism trial was conducted at a constant intake of .98 lb (447 g) dry matter. Straw samples were also analyzed for IVDMD and crude protein (CP).

Results

Cows fed NH_3 treated straw gained .88 lb (.4 kg) per day which was more ($P<.05$) than the average of the other treatments (Table 1). The cows fed the NH_3 treatment

Table 1. Effect of treatment of wheat straw on intake, digestibility and animal performance.

	Control	Sodium hydroxide	Liquid supplement	Ammonia
Cow trial				
Average daily gain, lb (kg)	.26 (.12)[b]	0 (0)[a]	.10 (.05)[a]	.88 (.40)[c]
Straw intake[d], lb (kg)	19.3 (8.8)[a]	17.3 (7.9)[a]	17.8 (8.1)[a]	23.0 (10.5)[b]
Sheep metabolism trial[e]				
Dry matter disgestibility, %	53.6[a]	53.5[a]	52.4[a]	59.7[a]
Intake, lb (g)	.99 (451)[a]	1.30 (592)[b]	1.32 (599)[b]	1.43 (648)[c]
In Vitro dry matter digestibility, %[f]	50.3[a]	54.2[b]	49.7[a]	57.7[c]

[a,b,c]Unlike superscripts in a row differ ($P<.05$) using orthogonal contrasts.
[d] Intake was estimated to be 80% of the straw fed.
[e] Rations similar to cow trial.
[f] Straw samples alone.

also had a significantly higher straw intake than all other treatments. The gain on the NaOH treated straw was below that of the control straw. The NaOH treated straw was noticeably moldy which may have affected cow intake and gain.

In the lamb metabolism trial the intake of the NH_3 treated straw ration was higher ($P<05$) than the other rations and the intake of control straw ration was lower ($P<.05$) than the liquid supplement or sodium hydroxide treated straw. The dry matter digestibility (DMD) of the NH_3 treated straw ration was higher than all other treatments by a minimum of 6 percentage units which is at least a 10% increase in digestibility. A similar response was observed with the *in vitro* dry matter digestibilities.

There were significant location effects on ammonia treatment in the stacks because of the ammonia rising. The top of the stack had a 2% higher ($P<.05$) IVDMD compared to the bottom of the stack and the uphill end of the stack had a 3.8% higher ($P<.05$) IVDMD compared to the downhill end of the stack. No differences were observed in IVDMD between the outside and inside of the bale which indicates that penetration of the NH_3 was not a problem. All straw in the stack had a higher IVDMD than the untreated straw which indicates that the treatment was effective throughout the stack.

Based on the CP content of the samples about 65% of the anhydrous ammonia injected was recovered in the straw. The current cost of NH_3 treatment by this method is about $7.80 per ton ($8.60 per metric ton) for ammonia [60 lb per ton (30 kg per metric ton) on an is as is basis]. If the polyethylene sheet was used only once the cost would be about $8.15/ton ($9.00 per metric ton) for a total treatment cost for materials of about $16.00 per ton ($17.60 per metric ton). It is possible that lower levels of NH_3 and reusable covers may be used in the future to lower treatment costs.

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Dehydrated Alfalfa for Cows

David Rock, John Ward, Terry Klopfenstein[1]

Cows fed dehydrated alfalfa as a supplemental nitrogen source gained more weight than those fed urea during lactation. Milk production as estimated by the weigh-suckle-weigh technique was greatest when 80% of the supplemental N source came from dehydrated alfalfa. No difference was observed in calf performance.

When formulated in a 20% crude protein equivalent pellet, dehydrated alfalfa increased weight gains of mature gestating beef cows when included at 80% of the supplemental N. Results were variable, suggesting that slowly degraded protein sources may not be applicable for gestating beef cows.

Slowly Degraded Proteins for Ruminants

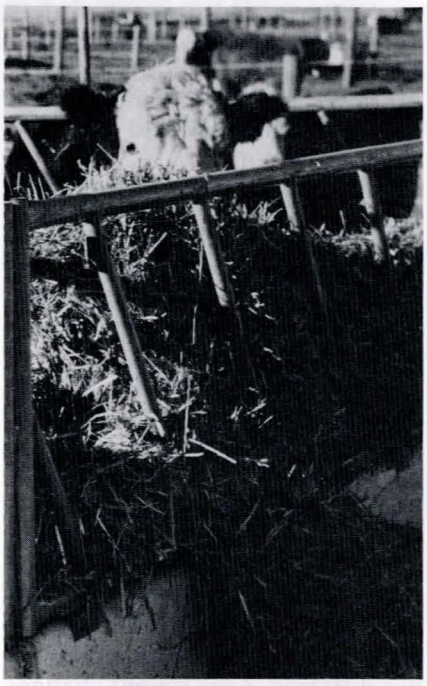
Protein for beef cows constitutes a significant part of feeding costs. Recent work has shown that slowly degraded protein sources (blood meal, corn gluten meal, distillers products, meat meal) and urea can be substituted for more traditional protein sources (soybean meal) to reduce the cost of protein supplementation. This research has been conducted with young growing animals whose requirement is high enough to allow adequate evaluation of slowly degraded sources.

Other animals for which slowly degraded protein sources may be applicable are 1) the lactating beef cow, and 2) the dry pregnant beef cow grazing residue forage. Protein requirements of these animals, particularly the lactating cow, may be quite high at certain periods. Also, for cows grazing corn stalks, residues have been shown to be low in available protein.

The objectives of these experiments were to 1) evaluate the use of a slowly degraded protein source (dehydrated alfalfa) in rations for lactating and gestating cows, and 2) determine the protein requirements of these animals for both degradable and slowly degradable protein.

Lactation Experiments

Two drylot lactation trials were conducted (Summer 1978 and 1979). Eighty crossbred Angus x Hereford cow-calf pairs were allotted to 1 of 4 treatments in both trials. Corn-cob: corn silage rations were supplemented with soybean meal (SBM), a low level of dehydrated alfalfa (LoDEHY), a high level of dehydrated alfalfa (HiDEHY) and/or urea. Cows were in mid-lactation (about day 115) with an average initial weight of 1050 lb (476 kg) at the start of the trials. Calves weighed 297 lb (135 kg).



Cows in drylot lactation study.

For both trials, .68 lb (.31 kg) protein was supplied by a natural source for the SBM and LoDehy treatments. Dehydrated alfalfa

(continued on next page)

Dehydrated Alfalfa

(continued from page 47)

supplied 2.02 lb (.92 kg) protein in the HiDehy treatment. Rations contained 55% total digestible nutrients and 9% crude protein equivalent (CPE) for Trial 1 (Table 1) and 55% TDN and 11% CPE in Trial 2 (Table 2) due to the inclusion of ammonia (NH_3) treated corn cobs (4% NH_3 at the time of ensiling, 35% of the ration dry matter) in the ration formulation. The intake of all treatments was limited to the *ad libitum* intake of the lowest consuming group.

When conducting drylot lactation trials, the fact that cows and calves have access to the ration confound most of the intake results. In these trials, calves were separated from the cows when the cows were fed (7:00 a.m.-4:00 p.m.). During this time, the calves were maintained in smaller pens adjacent to the large drylot pens. All calves were fed a ration of 2 lb (.91 kg) alfalfa hay and 2 lb (.91 kg) cracked corn.

Milk production was estimated with the weigh-suckle-weigh technique. Calves were weighed after being separated from the cows for 12 hours and again after 30 minutes with the cows. The average of three measurements (day 14, 45 and 76) in Trial 1 and two measurements (day 25 and 66) in Trial 2 were used to estimate milk production.

Cows fed rations supplemented with dehydrated alfalfa gained more weight ($P<.10$) in Trial 1 than those supplemented with urea (Table 4). Gains of cows fed SBM and UREA treatments were not different. Cow weight changes were not statistically different in Trial 2. If the trials were combined for statistical analysis, results were similar to Trial 1. Gains of HiDehy and LoDehy groups were superior to those in the Urea group. HiDehy supplemented cows gained more than the SBM groups. SBM supplementation was not different than Urea or LoDehy. Milk production was greatest for the HiDehy treatment. LoDehy supplemented cows produced more milk than urea controls. The HiDehy group produced more milk than all other groups in Trial 2 (Table 4).

On day 45 of Trial 2, milk samples were obtained for all cows and analyzed for milk fat and crude protein. These parameters were not affected by type of protein supplementation (Table 4).

Calf performance was not different in Trial 1 or 2. Slight advantages for natural protein, and particularly Dehy, were observed in the early periods of both trials, but these were not sustained to the end (Table 5).

Table 1. Diet composition for Trial 1.

Ingredient[b]	Dietary treatment[a] Urea	Soybean meal	LoDehy	HiDehy
Liquid supplement[c]	10.00	4.00	4.00	2.00
Corn cobs, ground	66.13	73.93	63.77	62.98
Corn silage	23.07	8.76	8.05	3.01
Soybean meal	–	6.40	–	–
Dehydrated alfalfa	–	–	17.27	23.07
Molasses, cane	–	6.00	6.00	8.00
Minerals and vitamins[d]	.80	.91	.91	.94

[a].68 lb (.31 kg) protein from natural sources SBM and LoDehy; 2.02 lb (.92 kg) protein from natural sources HiDehy.
[b]Ingredients on a dry matter basis.
[c]Supplement: 62.5% dry matter, 65% P, 32% crude protein equivalent from urea.
[d]Ca, P, salt, trace minerals, vit. A.

Table 2. Diet composition for Trial 2.[a]

Ingredient[b]	Dietary treatment Urea	Soybean meal	LoDehy	HiDehy
Liquid supplement[c]	10.55	–	–	–
Corn cobs, ground	30.96	29.05	18.89	17.21
Corn cobs, ground[d]	35.00	35.00	35.00	35.00
Corn silage	22.55	28.47	27.76	23.68
Soybean meal	–	6.40	–	–
Dehydrated alfalfa	–	–	17.27	23.07
Minerals and vitamins[d]	.94	1.08	1.08	1.04

[a].68 lb (.31 kg) protein from natural sources SBM and LoDehy; 2.02 lb (.92 kg) protein from natural sources HiDehy.
[b]Ingredients on a dry matter basis.
[c]Supplement: 62.5% dry matter, .65% P, 32% crude protein equivalent.
[d]Ca, P, salt, trace minerals, vit. A.

Table 3. Supplement composition for cow wintering—Trials 3 and 4.[a]

Ingredient[b]	Supplement treatment Urea	Soybean meal	LoDehy	HiDehy
Liquid supplement[c]	6.20	3.72	3.72	1.24
Corn cobs, ground	54.60	64.02	29.25	5.24
Corn starch	29.80	18.69	15.56	–
Bentonite	1.00	1.00	1.00	1.00
Soybean meal	–	14.17	–	–
Dehydrated alfalfa	–	–	42.07	84.12
Minerals and vitamins[c]	8.40	8.40	8.40	8.40

[a]1.9 lb (.86 kg) dry matter fed/hd/day, 2 lb (.91 kg) "AS IS" fed/hd/day. Formulated to supply .7 lb (.3 kg).
[b]Ingredients on a dry matter basis.
[c]p, salt, trace minerals, vit. A.

Wintering Experiments

Fifty-six Angus x Hereford cows in mid-gestation were allotted to four winter supplement treatments. Cows grazed a cornstalk field from November 6, 1978, to January 11, 1979, (66 days) in Trial 3 and from November 8, 1979, to January 18, 1980, (71 days) in Trial 4. The stocking rate for both trials was 1.5 acres per cow for the grazing period. Supplement formulation is shown in Table 3. Cows were fed 2 lb (.91 kg) per day of a 20% crude protein equivalent pellet [.7 lb (.3 kg) supplemented protein/cow/day]. The supplemental nitrogen was supplied by urea and a natural protein source (protein: NPN) in the following ratios: (Urea) 0:100; 60:40; (LoDehy) 60:40 and (HiDehy) 80:20.

Table 4. The effect of protein supplementation on cow weight change and milk production and composition during mid-lactation — Trials 1 and 2.

	Dietary treatment							
	Urea		Soybean meal		LoDehy		HiDehy	
Wt. change, Trial 1 lb (kg)	−30.3[a]	(−13.8)	−5.2[ab]	(−2.3)	12.1[b]	(5.6)	28.4[b]	(12.9)
Wt. change, Trial 2 lb (kg)	−47.9	(−21.8)	−37.7	(−17.1)	−30.7	(−14.0)	−14.0	(−6.4)
Milk production, lb/12 hr:								
Trial 1 lb (kg)	5.3[c]	(2.4)	6.4[cd]	(2.9)	7.0	(3.2)	8.6[e]	(3.9)
Trial 2 lb (kg)	6.3[c]	(2.9)	5.2[c]	(2.3)	5.83[c]	(2.7)	7.90[d]	(3.6)
Milk crude protein, %	3.1		3.0		3.1		2.9	
Milk fat, %	2.6		2.2		2.4		2.2	

[a,b]Means with different superscripts differ (P<.10)
[c,d,e]Means with different superscripts differ (P<.05)

Table 5. The effect of protein supplementation on performance of calves — Trials 1 and 2.

	Urea	Soybean meal	LoDehy	HiDehy
Avg. daily gain, lb/day (kg)				
Trial 1	1.2 (.5)	1.2 (.6)	1.3 (.6)	1.4 (.6)
Trial 2	1.3 (.6)	1.5 (.7)	1.4 (.7)	1.5 (.7)

Table 6. The effect of protein supplementation on cow weight change during wintering trials.

	Dietary treatment							
	Urea		Soybean meal		LoDehy		HiDehy	
Gain, lb (kg)								
Trial 1	32.4[a]	(14.7)	43.1[a]	(19.6)	10.9[a]	(5.0)	56.9[b]	(25.9)
Trial 2	44.6	(20.3)	63.5	(28.8)	59.5	(27.1)	62.1	(28.3)

[ab]Means with different superscripts differ (P<.05)

In Trial 3, the addition of 80% Dehy (percent supplemental N) increased the gain of cows when compared to urea supplementation (Table 6). No difference was observed in Trial 4.

Discussion

Two levels of dehydrated alfalfa supplementation were included in the experimental design to determin if protein was limiting in the LoDehy treatment. Responses to slowly degraded protein sources would not be expected if adequate protein was supplied by the base portion of the ration and the protein requirement of the animal was small. The protein requirement of lactating beef cows decreases as lactation progresses. A concentration of 9 to 10% crude protein equivalent has been suggested to adequately meet the protein requirement of lactating beef cows.

Response in both Trial 1 and 2 would suggest that there was a response to added bypass protein. Milk production trends support this observation. However, calf performance for the whole trial was not affected. A live calf and calf weaning weight may be the most important criteria of response when analyzing cow-calf trials. If so, supplementation of lactation rations with slowly degraded protein sources may not be necessary in mid to late lactation. Slight calf response to supplementation by dehydrated alfalfa may indicate that bypass protein may be beneficial. Research on-going at Nebraska will seek to answer this question in early lactation.

The results of dehydrated alfalfa supplementation of rations for mature beef cows in mid-lactation and early gestation were variable. Trends would indicate that a small response was obtained with dehydrated alfalfa. The protein requirement of the ruminant is at its lowest during mid-gestation just after the calf has been weaned. The supplemental protein needs may be met with the maximization of microbial protein production to be utilized with bypass protein supplied by the base component of the ration.

[1]David Rock is a Graduate Assistant. John Ward is Professor, Beef Nutrition. Terry Klopfenstein is Professor, Ruminant Nutrition.

Fat Level in Ground Beef

Dwight Loveday, Dennis Olson and Doug Zalesky[1]

Low fat (LF) ground beef had 3.8% less fat and fewer calories per gram on a raw basis than high fat (HF). However, after cooking, there were no differences in calories/gram between the LF and HF. The greater cooking loss of the HF patties can be attributed to the greater fat loss during cooking. The LF patties cost 4.4 cents more, yielded 4.7 gm more cooked product and had 9.3 more Kcal than HF patties. One week frozen storage had no adverse effects on ground beef characteristics.

Introduction

Ground beef accounts for 40-45% of the total amount of beef consumed. Fifty percent of U.S. households use ground beef at least once a week. Products labeled ground beef cannot exceed 30 percent fat by weight. Because of the wide allowance for fat many supermarkets offer ground beef at two or more fat levels. This meat may be labeled in several ways: "ground round", "ground chuck", "ground beef", "chopped beef" or "hamburger". Prices usually vary according to fat level but it is difficult to relate the actual cost to the quality of ground beef. Previous research has shown "ground meat" to range in fat content from 6 to 49 percent.

Although most research indicates that as fat content increases cooking losses also increase, a recent USDA study found no difference in cooking loss from ground beef varying in percentage of fat. Cooking loss and price per pound (which is related to fat content) have an influence on cost per serving. Fat levels of 15-30% appear to be the most palatable.

Freezing ground beef after purchase for a short period of time is a common practice among households. Recent research at Iowa

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Fat Level

(continued from page 49)

State University showed that freezing ground beef patties with a mechanical refrigerator decreased consumer panel scores when compared to rapid freezing with liquid nitrogen or carbon dioxide.

Objectives of this study were: 1) to determine the economic and calorie value of ground beef having different fat levels, and 2) to determine the effect of short term freezer storage on ground beef characteristics.

Collecting cooking loss data on ground beef patties.

Procedures

Three supermarkets in Lincoln, Nebraska were selected. Each supermarket belonged to a different chain of like supermarkets across the country. Ground beef selected was labeled to contain about 20% (LF) and 30% (HF) fat. Ground beef was purchased from each store one day per week for three weeks. The purchase packages contained 500 gm of ground beef. Each package was divided into two equal portions. One half was rewrapped in a plastic wrap similar to wrap used in supermarkets and placed in a –18 C (O F) refrigerator freezer for six days. Frozen samples were removed from the freezer and thawed at 4 C (39 F) for 24 hours and then handled the same as the refrigerated samples.

Ground beef (100 gm) was formed into patties 12 mm thick and 100 mm in diameter using a standard-size cup and plunger attached to an Instron Universal Testing Machine.

Patties were cooked in a dry, cool electric skillet set at 150 C (300 F) and cooked until an internal temperature of 70 C (158 F) was reached. Patties were blotted dry and patty circumference, height and weight were measured.

Results

The effects of fat level on ground beef characteristics are shown in Table 1. In meat products, protein content generally remains at a fairly constant level, with fat and moisture products varying reciprocally. As expected, the HF group had higher raw and cooked fat percentages and lower raw and cooked moisture percentage than LF group. Because fat is a major contributor to the calorie content of a meat product, the HF group had more calories per gram in the raw product. However, after cooking, no difference in calories was found. The HF group also had a higher cooking loss.

Combining the cooking loss and the composition of the cooked patty, the HF patty lost 24.3 gm of moisture and 9.4 gm of fat, whereas, the LF patties lost 23.4 gm of moisture and 6.4 gm of fat during cooking. These data indicate that the HF group loses more fat during cooking than the LF group while moisture loss was nearly the same. This is also substantiated by the smaller cooked patty volume from the HF group. Consequently, the greater fat loss during cooking of HF patties accounts for the comparable caloric content between the cooked HF and LF patties.

In conclusion, the LF group yielded 4.7 gm per patty more after cooking, cost 4.4 cents more per patty and yielded 9.3 Kcal more per patty then the HF group. The greater calorie per patty for the LF group is due to the larger patty. The patty of the HF group would be slighly smaller than the LF group.

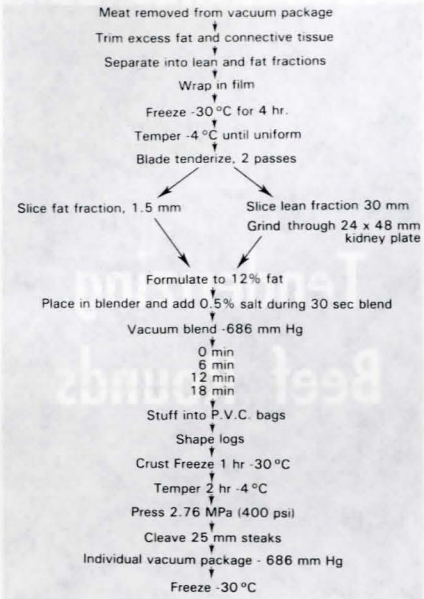
The effects of freezer storage on ground beef characteristics are shown in Table 1. None of the ground beef characteristics were affected by freezing for one week. Since the product was frozen for only one week before cooking and analysis, very little change would have been expected. Longer freezer periods may have shown some differences. These results indicate that consumers should not expect any significant changes in their ground beef that has been frozen for one week.

Table 1. Effect of fat level and freezer storage on ground beef characteristics.

	Low fat		High fat	Fresh	Frozen
Raw moisture (%)	63.7	*	60.7	62.2	62.2
Raw fat (%)	17.9	*	21.7	19.8	19.8
Raw calories (cal/gm)	2971	*	3292	3131	3131
Cooked moisture (%)	57.7	*	55.9	56.7	56.9
Cooked fat (%)	16.5	*	18.9	17.4	18.0
Cooked calories (cal/gm)	3205		3294	3203	3295
Cooking loss (%)	30.2		34.9	32.5	32.6
Volume of cooked patty (cm^3)	91.0		81.4	85.4	87.0

*Denotes adjacent means in each row are significantly different ($P<.05$).

[1]Dwight Loveday is Extension Meats Specialist. Dennis Olson is Assistant Professor—Meats. Doug Zalesky was an undergraduate student.



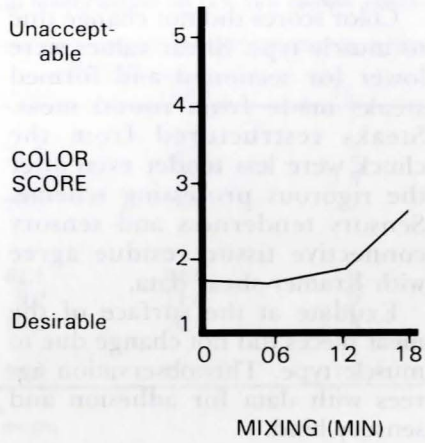


Figure 2. Effect of mixing time on subjective color score.

Figure 1. Processing scheme for beef restructured into sectioned and formed beef steaks.

A New Concept

Sectioned and Formed Beef Steaks

A. M. Booren and R. W. Mandigo[1]

Acceptable sectioned and formed beef steaks were produced from Standard rounds and Choice chucks. Meat pieces blended for 12 minutes resulted in the most desirable steaks. Fresh color was highly desirable in steaks processed with 12 minute mixing. Longer mixing times caused color deterioration. Maximum binding was achieved after 12 minute mixing and was similar for muscle types.

Differences due to vacuum mixing were small and conflicting when binding was considered. The present study indicates that the use of vacuum mixing equipment for sectioned and formed steak production would be unwarranted.

Sectioned and Formed Steaks

During the 1970's meat researchers developed new processing systems to make steak-like products utilizing low cost trimmings and difficult to merchandise wholesale cuts.

New equipment designs have increased the processor's ability to mechanically alter fresh beef tissue and manipulate it into more desirable shapes. The end result has led to the concept of "flaked and formed" or restructured steaks. These steaks are low-cost, uniform, completely edible, and resemble a fresh intact muscle in flavor, color and textural properties. Flaked and formed restructured beef steaks have been well received by the consumer, particularly in the hotel, restaurant and institutional (HRI) industry.

Research at the Loeffel Meat Laboratory has led to development of processed meat products which are closer in textural properties to the intact muscle. Massaging and tumbling techniques have created a product made up of large meat pieces bonded into a single mass. The technique involves using abrasion and impact energy to damage muscle tissue thereby releasing sticky protein exudates. Upon heating, the exudate binds the pieces into an intact section. A desirable sectioned and formed beef steak can be made by binding larger muscle pieces with the exudate of muscle origin. The only additive required is 0.5% salt.

Sectioned and formed beef steaks were manufactured to contain 12% fat using the processing schedule shown in Figure 1. Other fat levels can be formulated. The steaks were prepared from two basic meat types: Choice, Yield Grade 3 boneless chucks, or Standard boneless rounds. The affect of mixing time and vacuum mixing were evaluated for optimum binding, color, rancidity and texture during production and storage.

Affect of Mixing Time

Color scores significantly increased as mixing time increased (Figure 2). A significant ($P<.01$) increase in color score at 18 minutes mixing relates to a less desirable surface color in the finished steaks. However, the score remained in the desirable area of the scale.

The thiobarbituric acid values (TBA), a measure of rancidity, did not change with mixing time after 90 days storage at −30°C (Table 1). All TBA values were low and

Table 1. The effects of mixing time on restructued steaks.

	Mixing time 0	6	12	18
TBA value (90 days)	.4	.4	.3	.3
Kramer shear, kg/g[a]	6.2	5.7	5.4	4.7
Cooking yield, %[a]	70.6	71.8	75.3	77.4
Exudate, mg/cm²[a]	10.3	48.9	114.1	223.8
Sensory juiciness[ac]	4.3	4.7	5.4	5.7
Sensory flavor[bc]	4.6	5.2	5.7	5.6
Sensory tenderness[a]	5.4	5.7	5.6	5.9

[a]Means significantly different ($P<.01$).
[b]Means significantly different ($P<.05$).
[c]Scale 1 to 8 with 8 being extremely desirable and 1 undesirable.

Table 2. The effects of muscle type on restructued steaks.

	Chuck	Round
Fat %[a]	13.7	11.7
Color score	2.0	1.8
Kramer shear, kg/g[a]	5.7	5.3
Adhesion, g	72.9	68.0
Exudate, mg/cm²	98.0	100.4
Sensory bind[b]	3.8	3.5
Sensory tenderness[ab]	5.4	5.9
Sensory connective tissue residue[ab]	5.2	6.3

[a]Means significantly different ($P<.01$).
[b]Scale 1 to 8 with 8 being extremely desirable and 1 undesirable.

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Formed Beef Steaks

(continued from page 51)

acceptable with respect to rancidity.

Kramer shear values decreased as mixing increased—indicating a more tender product. This tenderizing effect is also reflected in sensory tenderness and will be an important consideration when restructuring with less tender muscles.

Cooking yield increased (P<.01) with mixing time. Juiciness and flavor also increased with mixing time, due to more protein binding.

Protein exudates increased 10 times after 12 minutes of mixing and 20 times after an 18 minute mix. When exudate amounts are compared to actual binding of meat pieces (Figure 3) there is a significant linear response (P<.01) and a significant quadratic response (P<.01). Adhesion values of 47.1, 78.1 and 98.0g have been obtained for intact beef psoas, longisimus and semitendinoisis, respectively, which are in the same range of values as for the sectioned and formed steaks.

Adhesion and sensory bind are measures of the steak to hold together during cooking and upon chewing.

Affect of Muscle Type

Fat content changed due to muscle type (Table 2). This is due to the higher amounts of inter- and intra-muscular fat (seam fat and marbling, respectively) present in the chuck, making it more difficult to formulate to a constant fat level.

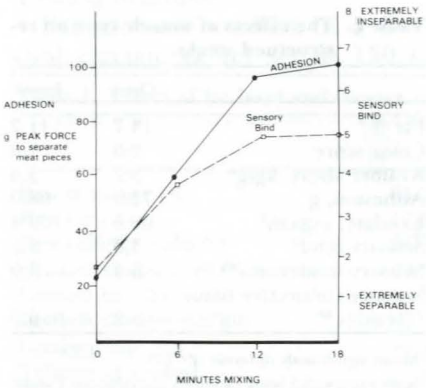

Figure 3. Effect of mixing time on adhesion and sensory bind.

Color scores did not change due to muscle type. Shear values were lower for sectioned and formed steaks made from round meat. Steaks restructured from the chuck were less tender even after the rigorous processing scheme. Sensory tenderness and sensory connective tissue residue agree with Kramer shear data.

Exudate at the surface of the meat pieces did not change due to muscle type. This observation agrees with data for adhesion and sensory bind.

Thus, acceptable binding can be achieved with any one muscle or a combination of muscles from beef carcass.

Affect of Vacuum Mixing

Color scores were higher (P<.05) for vacuum processed sectioned and formed steaks (Table 3) indicating less desirable colors resulted from vacuum mixing. However, all scores are in the desirable range.

Less exudate (P<.05) was produced on the surface of beef pieces subjected to vacuum mixing. There was less binding (P<.05) in the no-vacuum treatments as measured by the sensory panel. Adhesion values appeared to contradict these observations but were not significant. Shear values, TBA values and other sensory traits did not change due to vacuum treatment.

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[1]A. M. Booren is Assistant Professor, Food Science and Nutrition, Michigan State University. R. W. Mandigo is Professor—Meats.

Table 3. The effects of vacuum mixing on restructured steak.

	Vacuum	No vacuum
Color score[a]	2.3[a]	1.8[b]
TBA value (60 days)	.3	.4
Kramer shear, kg/g	5.6	5.4
Adhesion, g	63.3	86.4
Exudate, mg/cm^2[a]	79.4[a]	114.4[b]
Sensory bind[ab]	4.9[a]	4.0[b]
Sensory juiciness[b]	4.9	5.0
Sensory flavor[b]	5.2	4.9
Sensory tenderness[b]	5.4	5.5
Sensory connective tissue residue[b]	5.5	5.6

[a]Mean significantly different (P<.01).

[b]Scale 1 to 8 with 8 being extremely desirable and 1 undesirable.

Tenderizing Beef Rounds

R. W. Mandigo and D. G. Olson[1]

Mechanical tenderization had a marked tenderizing effect on round steaks. Needle size differences had little effect on tenderness. The processors who use mechanical tenderization have definite improvements in tenderness assurance.

Introduction

Beef round steaks were much more tender when tenderized mechanically with stainless steel needles in a tenderizer. Tenderness of beef steaks varies immensely. Muscles within a carcass and between different carcasses vary in tenderness due to connective tissue amount and the amount of muscle shortening following slaughter. There are no measures that adequately measure tenderness before the meat is cooked. Consequently, many processors rely on mechanical tenderization of steaks and roasts to give the margin of assurance that the meat will be tender when it is consumed.

Mechanical Tenderness

Mechanical tenderization involves passing a steak or wholesale cut through a machine equipped with a bank of needles which penetrate the meat. Hundreds of small cuts are made through the meat to break up the connective tissue and

Table 1. Effect of blade size used in mechanical tenderization on raw and cooked proximate analyses and cooking loss.[a]

	Control	Blade size 1.9 mm	3.2 mm	S.E.
Raw				
Moisture (%)	71.2	71.7	71.5	.9
Fat (%)	9.0	7.5	9.0	1.3
Protein (%)	19.5	20.0	18.9	.7
Cooked				
Moisture (%)	60.4	61.3	61.4	1.0
Fat (%)[b]	10.8	9.2	11.0	.9
Protein (%)[b]	28.0	28.2	26.6	.6
Cooking loss (%)	23.8	23.3	21.2	1.3

[a]Means and Standard Errors are the average of 9 observations.
[b]Significant differences between 1.9 mm and 3.2 mm needles (P<.05).

muscle fiber network. These cuts are so small that visual observation is difficult. Because of widespread commercial interest, considerable research has been done with the concept.

Several blade sizes have been developed for the machines. There have been few results developed on the differences between the various sizes of blades or needles.

Objectives of this study were to determine the effect of two different blade sizes on the tenderizing of round steak. Secondly, does blade tenderizing improve tenderization of round steak over the non-tenderized meat.

Steak Preparation

Nine inside beef rounds (USDA Good Grade) were used and each was divided into thirds and assigned to three treatments. The treatments were: (1) control, (2) 1.9 mm blade width, or (3) 3.2 mm blade width. The control pieces were not tenderized, while the other treatments were tenderized through a Bettcher Model TR-2 Mechanical Tenderizer.

After tenderizing, the meat was trimmed of excess fat, wrapped in film, crust frozen at −37°C for 3 hours and then tempered at −4°C for 16-18 hours. Each piece was pressed into a steak shape and sliced 2.5 cm thick for steaks. Steaks were vacuum packaged, labeled, frozen and stored at −32°C for later analysis.

One steak from each treatment was analyzed for composition. Moisture, fat and protein were determined on the raw steaks.

Another steak was oven-roasted to an internal temperature of 70°C. Thaw and cooking loss were determined. Steaks were presented to a sensory panel and the Instron Warner-Bratzler shear was used for tenderness evaluation. Cooked composition was determined.

The sensory panel of eight people evaluated the steaks for initial tenderness (after the first few chews), flavor, juiciness, overall tenderness and connective tissue residue. All ratings were on an eight point scale. The score 8 was the most tender, juicy, flavorful and the least amount of connective tissue residue.

Effects of Tenderization

Mechanical tenderization and blade size did not alter the composition or the cooking loss to any great extent (Table 1). The only significant difference in proximate composition in either the raw or cooked samples occurred between the different blade sizes for fat and protein content. This difference was probably due to slight differences in the uniformity of the steaks.

Mechanical tenderizing greatly improved the tenderness of the round steak as shown by higher initial and over tenderness ratings (Table 2.). The higher connective tissue residue values also indicate considerable improvement in tenderness (5.6 for both blade sizes compared to 4.1 for the controls).

Further evidence is seen in the Warner-Bratzler shear values as they were lowered in the mechanically tenderized steaks. Mechanical tenderization reduced the force and work required to shear the samples of round steak. The cutting action of the needles caused the disruption of the muscle fibers and connective tissue to make the steaks more tender.

Blade Size Differences

The larger blade sizes (3.2 mm) tenderized the steaks slightly more. Both initial and overall tenderness were high for the large needles. Flavor and juiciness were not influenced by needle size or by tenderizing the steaks. The Warner-Bratzler shear showed no significant differences between the two needle sizes.

[1]R. W. Mandigo is Professor—Meats. D. G. Olson is Associate Professor, Animal Science Dept. Iowa State Univ. Appreciation expressed to Bettcher Industries, Vermillion, OH.

Table 2. Effect of blade size used in mechanical tenderization on sensory measurers[a] and Warner-Bratzler Shear (WBS).[b]

	Control	Blade size 1.9 mm	3.2 mm	S.E.
Initial tenderness[cd]	3.6	5.7	6.3	.14
Juiciness	4.6	4.8	4.7	.15
Flavor	4.8	5.0	5.1	.13
Overall tenderness[cd]	4.0	5.9	6.4	.12
Connective tissue residue[c]	4.1	5.6	5.6	.19
WBS peak force (kg)[b]	9.0	7.5	7.3	.69
WBS area (cm^2)[b]	17.4	14.1	13.4	1.3

[a]Means and Standard Errors (n=72). Sensory Scale 8 point with 8 being extemely tender, juicy, intense flavor and no connective tissue residue.
[b]Means and Standard Errors (n=9).
[c]Significant control vs. mechanical tenderizing effect (P<.05).
[d]Significant 1.9 mm vs. 3.2 mm blade size comparison (P<.05).

Cattle on breeding experiments.

Industry Genetic Change

M. K. Nielsen[1]

The impact of different industry structures for practicing selection is described using a seedstock and commercial levels arrangement. Over time, the genetic change made in the industry relies completely *upon the change made in the seedstock herds. This emphasizes the necessity for maximizing desirable genetic change in the seedstock herds.*

Gains made from differing amounts of male and female selection in commerical herds become fixed *over time and are equal to the expected one generation gain. With artificial insemination, the opportunity may exist to utilize the same sires in the seedstock and commercial herds. Then the commerical herds would lag behind the seedstock herds only if there are differences between them in female selection.*

Introduction

The genetic change that can occur in the national beef cattle population is a function of selection and crossbreeding applications. Responses that occur due to selection depend upon selection criteria, identifying genetic merit, and the industry structure for selection emphasis and genetic change flow.

Selection criteria have changed over time and are under continual scrutiny in our research and breeding programs. Procedures for identifying genetic worth or breeding value of cattle are updated and improved based on results from research studies. The structure for selection emphasis and genetic change flow has impact on the lag that exists between different levels in the industry. This article focuses on the impact of different industry structures for making genetic change with selection.

General Structure

The structure of the national beef cattle breeding population, with respect to source and use of selected replacement animals, has evolved into two divisions: seedstock and commercial. If none of the calves in a herd are used for breeding stock in another herd, then it would be defined a commercial herd. If any of the calves of a herd are used for breeding stock in another herd, then it would be defined a seedstock herd.

Traditionally, our registered herds have been thought of as seedstock herds. However, registered herds that do not pass on breeding stock are not seedstock herds. In many cases seedstock herds could be subdivided into elite and multiplier herds. The elite herds are at the top of the breeding structure which assumes they have the best genetic level. Multiplier herds multiply in animal numbers, (not genetic level) the genetic material available from the elite herds for use in commerical herds.

Privately owned companies as well as cooperatives that have entered the seedstock business follow some seedstock—commerical population relationship in a more organized manner. This is en-

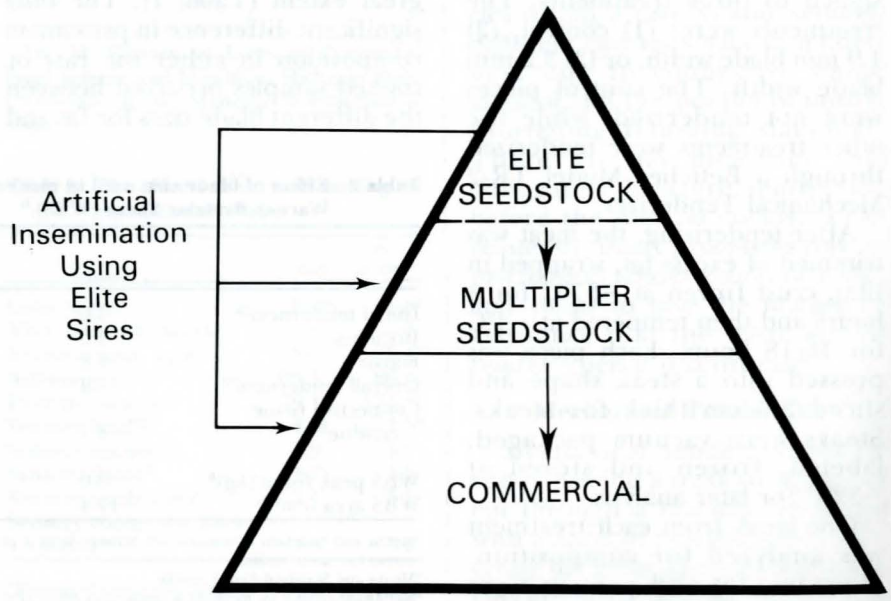

Figure 1. Pyramid of industry genetic change flow.

hanced due to vertical integration that they have control over.

This seedstock to commercial herd flow of genetic material is shown in Figure 1. This pyramid has arrows to indicate the flow of breeding stock. Many variations of industry structure pyramids (e.g. using males from the elite in both the multiplier and commercial levels, returning the best females from the commercial to the seedstock herds, etc.) could be put together. To do this in an organized, systematic manner requires vertical integration and a large organization (i.e. cooperative or company).

This article will study a relatively simple structure, but the results are true across all structures. A seedstock herd utilizing replacement males and females selected from within and a commercial herd utilizing males from the seedstock herd and females from within the commercial herd will be investigated.

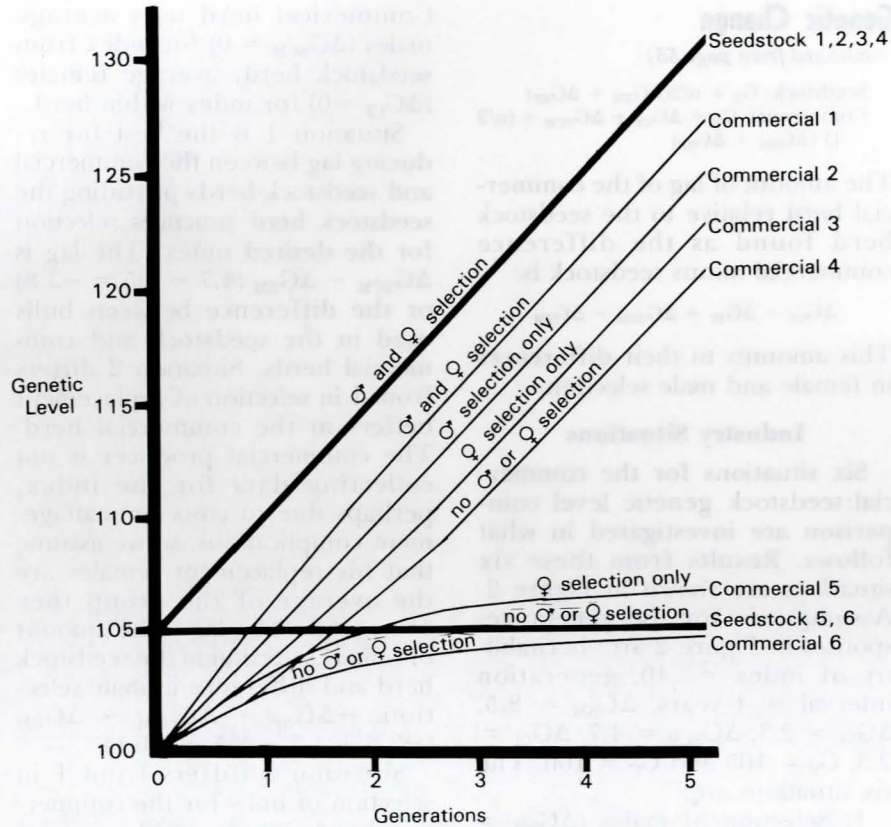

Figure 2. Response in seedstock (S) and commercial (C) herds in situations 1-6.

Assumptions

Assume that the seedstock and commercial herds are large in numbers so that inbreeding does not pose an immediate problem and genetic superiority of selected animals is more predictable generation to generation. Assume that improvement is desired in some index with the genetic or breeding value level defined as G. Let the average level of the seedstock herd at generation 0 (our starting point) be G_S and for the commercial herd, G_C.

The best bulls, based on the index, in the seedstock herd are used in the seedstock herd; the second best bulls are used in the commercial herd. The best females are selected and used within their own herds. The superiority of selected males and females relative to the generation-herd group in which they are *born* is represented by ΔG in the following:

ΔG_{SM} = genetic superiority of males used in seedstock herd

ΔG_{SF} = genetic superiority of females used in seedstock herd

ΔG_{SCM} = genetic superiority of seedstock males used in commercial herd

ΔG_{CF} = genetic superiority of females used in commercial herd

Using the relationship of expected average genetic level of offspring equals half the average level of sires plus half the average genetic level of dams we have the following in the seedstock herd:

Generation	Seedstock Herd Genetic Level
0	G_S
1	$G_S + 1/2(\Delta G_{SM} + \Delta G_{SF})$
2	$G_S + (\Delta G_{SM} + \Delta G_{SF})$
3	$G_S + 3/2(\Delta G_{SM} + \Delta G_{SF})$
4	$G_S + 2(\Delta G_{SM} + \Delta G_{SF})$
.	
.	
.	
n	$G_S + n/2(\Delta G_{SM} + \Delta G_{SF})$

Note: Sires born in generation 0 producing progeny in generation 1 have average value $G_S + \Delta G_{SM}$. Likewise dams of generation 1 progeny have average value $G_S + \Delta G_{SF}$. Thus the generation 1 average value is $1/2(G_S + \Delta G_{SM}) + 1/2(G_S + \Delta G_{SF}) = G_S + 1/2(\Delta G_{SM} + \Delta G_{SF})$. The same procedure follows for succeeding generations.

For the commercial herd where sires come from the seedstock herd and dams come from within the commercial herd and assuming equal rate of replacement of males and females to seedstock herd (equal generation interval):

Generation	Commercial Herd Genetic Level
0	G_C
1	$\frac{1}{2}G_C + \frac{1}{2}G_S + \frac{1}{2}\Delta G_{CF} + \frac{1}{2}\Delta G_{SCM}$
2	$\frac{1}{4}G_C + \frac{3}{4}G_S + \frac{3}{4}\Delta G_{CF} + \frac{3}{4}\Delta G_{SCM} + \frac{1}{4}\Delta G_{SM} + \frac{1}{4}\Delta G_{SF}$
3	$\frac{1}{8}G_C + \frac{7}{8}G_S + \frac{7}{8}\Delta G_{CF} + \frac{7}{8}\Delta G_{SCM} + \frac{5}{8}\Delta G_{SM} + \frac{5}{8}\Delta G_{SF}$
4	$1/16G_C + 15/16G_S + 15/16\Delta G_{CF} + 15/16\Delta G_{SCM} + 17/16\Delta G_{SM} + 17/16\Delta G_{SF}$
.	
.	
.	
n	$(\frac{1}{2})^n G_C + [1 - (\frac{1}{2})^n][G_S + \Delta G_{CF} + \Delta G_{SCM}] + [n/2 - 1 + (\frac{1}{2})^n][\Delta G_{SM} + \Delta G_{SF}]$

In the long run after several generations of selection (n gets large), the average herd levels are (because $(1/2)^n$ gets very small):

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Genetic Change

(continued from page 55)

Seedstock: $G_S + n/2(\Delta G_{SM} + \Delta G_{SF})$
Commercial: $G_S + \Delta G_{CF} + \Delta G_{SCM} + (n/2 - 1)(\Delta G_{SM} + \Delta G_{SF})$

The amount of lag of the commercial herd relative to the seedstock herd found as the difference commercial minus seedstock is:

$$\Delta G_{CF} - \Delta G_{SF} + \Delta G_{SCM} - \Delta G_{SM}$$

This amounts to their differences in female and male selection.

Industry Situations

Six situations for the commercial:seedstock genetic level comparison are investigated in what follows. Results from these six situations are shown in Figure 2. Assumptions for the genetic responses in Figure 2 are: heritability of index = .40, generation interval = 4 years, $\Delta G_{SM} = 8.5$, $\Delta G_{SF} = 2.3$, $\Delta G_{SCM} = 4.7$, $\Delta G_{CF} = 2.3$, $G_S = 105$ and $G_C = 100$. The six situations are:

1. Selection of males ($\Delta G_{SM} = 8.5$) and females ($\Delta G_{SF} = 2.3$) for index in seedstock herd. Commercial herd uses above average males ($\Delta G_{SCM} = 4.7$) for index from seedstock herd; selected females ($\Delta G_{CF} = 2.3$) for index from within herd.
2. Seedstock herd same as in 1. Commercial herd uses above average males ($\Delta G_{SCM} = 4.7$) for index from seedstock herd; average females ($\Delta G_{CF} = 0$) for index from within herd.
3. Seedstock herd same as in 1. Commercial herd uses average males ($\Delta G_{SCM} = 0$) for index from seedstock herd; selected females ($\Delta G_{CF} = 2.3$) for index from within herd.
4. Seedstock herd same as in 1. Commercial herd uses average males ($\Delta G_{SCM} = 0$) for index from seedstock herd; average females ($\Delta G_{CF} = 0$) for index from within herd.
5. Seedstock herd uses average males ($\Delta G_{SM} = 0$) and females ($\Delta G_{SF} = 0$) for index. Commercial herd uses average males ($\Delta G_{SCM} = 0$) for index from seedstock herd; selected females ($\Delta G_{CF} = 2.3$) for index from within herd.
6. Seedstock herd same as in 5. Commerical herd uses average males ($\Delta G_{SCM} = 0$) for index from seedstock herd; average females ($\Delta G_{CF} = 0$) for index within herd.

Situation 1 is the best for reducing lag beween the commercial and seedstock herds providing the seedstock herd practices selection for the desired index. The lag is $\Delta G_{SCM} - \Delta G_{SM}$ ($4.7 - 8.5 = -3.8$) or the difference between bulls used in the seedstock and commercial herds. Situation 2 differs from 1 in selection of replacement heifers in the commercial herd. The commercial producer is not collecting data for the index, perhaps due to costs or management complications, so we assume that his replacement females are the average of the group they come from. The lag is the amount of female selection in the seedstock herd and difference in male selection, $-\Delta G_{SF} + \Delta G_{SCM} - \Delta G_{SM}$ ($-2.3 + 4.7 - 8.5 = -6.1$).

Situation 3 differs from 1 in selection of bulls for the commercial herd. This would occur if index values are not available on bulls for the commercial producer to use or if the commercial producer can only afford the average bull from the seedstock herd. However, the commercial producer still selects female replacements on the index. The lag is the amount of bull selection in the seedstock herd, $-\Delta G_{SM}$ (-8.5). Situation 4 is a combination of 2 and 3. The lag is the amount of female and male selection in the seedstock herd, $-\Delta G_{SF} - \Delta G_{SM}$ ($-2.3 - 8.5 = -10.8$).

Situations 5 and 6 have the commercial producer obtaining bulls from a seedstock herd which does not practice selection on the desired index. If the commercial producer wants to select his replacement heifers for the desired index as in Situation 5, he will end up exceeding the seedstock herd by the amount of heifer selection applied each generation, ΔG_{CF} (2.3). Situation 6 shows the commercial herd becoming the same as the seedstock herd after a few generations.

Applications in Industry

The costs for making genetic change by selection are those in identifying breeding values in the herds from which replacement males and females are chosen. The various costs in testing procedures, special facilities, data handling, etc., must be paid by the increased value of the commercial animals.The optimum use of selection in the beef industry would depend to some extent on the magnitude of these costs.

Comparison of Situations 1 - 4 to 5 - 6 shows the impact of maximizing desirable genetic change in the seedstock, especially the elite or top level, herds. In the long run, the rate of change in the commercial industry is *completely* dependent upon the rate of change in the seedstock herds if the seedstock herds continue to be the source of bulls. The herd-improving seedstock producers receive the credit for their improved genetic level. But more importantly, they bear the responsibility for genetic change for the whole industry.

The costs of selecting replacement heifers in the commercial herd on the desired index (data collection, management, etc.) must be weighed against the one generation superiority of selected heifers versus average heifers. Comparison of Situations 1 to 2 and 3 to 4 show the extra gained by the extra effort in the commercial herd. One must remember that maintenance of the *fixed*, not increasing, advantage from heifer selection in the commercial herd can only occur with continued selection on the index and its associated costs.

Utilization of artificial insemination to sire all calves in the commercial herd by the same bulls used in the seedstock herd would change ΔG_{SCM} to be the same as ΔG_{SM}. In Situations 1 and 3 above, there would be *no* lag or difference between the commercial and seedstock herds; the lag in Situations 2 and 4 would be only the amount of heifer selection in the seedstock herd or $-\Delta G_{SF}$. Thus the real effect of artificial insemination is to reduce the lag.

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