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INTAKE AND DIGESTION OF LOW-QUALITY MEADOW HAY BY STEERS AND PERFORMANCE OF COWS ON NATIVE RANGE WHEN FED PROTEIN SUPPLEMENTS CONTAINING VARIOUS LEVELS OF CORN[1]

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ABSTRACT

Two trials were conducted to evaluate the effects of corn in protein supplements fed to cattle receiving low-quality forages. In Trial 1, four ruminally cannulated steers (avg BW 550 kg) and four intact steers (avg BW 270 kg) were used in a replicated latin square to determine intake and digestibility of a low-quality meadow hay (4.3% CP) when fed no supplement (NS), 1.12 g CP/kg BW (PS), 1.12 g CP/kg BW with corn supplying 1.98 g starch/kg BW (PLC) or 1.12 g CP/kg BW with corn supplying 3.96 g starch/kg BW (PHC). Hay DMI decreased ($P = .001$) and total diet DMI increased ($P = .001$) quadratically as supplemental corn increased. Diet DM digestibility increased ($P = .004$) and forage DM and hemicellulose digestibility decreased ($P \leq .018$) quadratically as level of corn in the diet increased. In Trial 2, 135 cows received either ear corn (1.16 kg TDN and 127 g $CP \cdot hd^{-1} \cdot d^{-1}$), ear corn plus protein (1.16 kg TDN and 290 g $CP \cdot hd^{-1} \cdot d^{-1}$) or protein (.72 kg TDN and 290 g $CP \cdot hd^{-1} \cdot d^{-1}$) while grazing native Sandhills winter range for 112 d and while receiving hay (10% CP) during the following 60-d calving period. Cows that received ear corn lost ($P < .001$) more weight than cows fed ear corn plus protein supplement, which lost more weight than cows fed only protein supplement (–54, –18 and 6 kg, respectively) during the 112-d winter grazing period. Cows that received ear corn and ear corn plus protein gained more ($P < .001$) weight during calving and summer grazing (after supplement was withdrawn) than protein-supplemented cows. Reproductive performance was not affected ($P > .705$) by treatments.

(Key Words: Beef Cattle, Corn, Digestibility, Intake, Performance, Protein.)

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Introduction

The effect of supplementation on utilization of forage often is overlooked. Intake or digestion of low-quality forage may be depressed when cattle are fed supplements containing high amounts of cereal grains (Campbell et al., 1969; Chase and Hibberd, 1987). In contrast, intake of forage often increases when supplements containing protein from oil meal products are fed to cattle and sheep (McCollum and Galyean, 1985; Krysl et al., 1987, Stokes et al., 1988).

Effects of supplements containing combinations of oil meals and cereal grains on forage utilization have been variable (Williams et al., 1953; Fontenot et al., 1955; Elliott, 1967a; Rittenhouse et al., 1969). Furthermore, performance of animals supplemented with various levels of protein and energy has not been consistent (Norman, 1963; Bellows and Thomas, 1976; Davis et al., 1977; Hennessy et al., 1981). Research reported in this paper was designed to study the effect of increasing amounts of corn in a protein supplement on intake and digestion of a low-quality meadow hay by steers and to evaluate performance of cows receiving ear corn with and without a conventional protein supplement.

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TABLE 1. FORMULATION AND DAILY NUTRIENT INTAKE OF PROTEIN SUPPLEMENTS FED IN TRIAL 1

Item	Starch from corn, g/kg BW		
	0 (PS)[a]	2 (PLC)[a]	4 (PHC)[a]
Ingredient, %[b]			
Corn		57	77
Soybean meal	70	35	23
Corn gluten meal	28	7	
Monosodium phosphate	2	1	
Nutrient, g/kg BW[c]			
DM	2.3	4.6	7.0
TDN	1.7	3.5	5.4
Total protein	1.12	1.12	1.12
Corn protein		.19	.39
Corn gluten meal protein	.39	.20	
Soybean meal protein	.73	.73	.73
Starch		1.98	3.96

[a]PS = protein–no corn supplement; PLC = protein–low corn supplement; PHC = protein–high corn.

[b]DM basis.

[c]Calculated values from feed tables (NRC, 1984).

Experimental Procedures

Trial 1. Four crossbred steers (avg BW 550 kg), each fitted with a permanent 10.2-cm i.d. ruminal cannula, and four crossbred intact steers (avg BW 270 kg) were used in a replicated 4 × 4 latin square to determine intake and digestibility of grass hay when being fed isonitrogenous supplements containing various amounts of corn. The four treatments (Table 1) were no supplement (NS) and three supplements each providing 1.12 g CP/kg BW daily but providing different amounts of starch from corn. Each of the three supplements supplied .73 g CP from soybean meal/kg BW. Corn gluten meal was used to adjust supplements to a constant corn protein level. Hence, the protein-no corn supplement (PS) supplied .39 g of CP from corn gluten meal/kg BW. The protein-low corn supplement (PLC) supplied .20 and .19 g of CP from corn gluten meal and corn/kg BW, respectively. The protein-high corn supplement (PHC) supplied .39 g of CP from corn/kg BW (PHC). The three supplements supplied 0, 2 and 4 g of starch from corn/kg BW, respectively. Forage was low-quality hay (Table 2), consisting of both warm- and cool-season grasses, harvested from a subirrigated meadow in August 1987 and chopped with a tub grinder through a 5-cm screen. Predominant warm-season species were big bluestem (*Andropogon gerardii* Vitman), prairie sandreed (*Calamovilfa longifolia* [Hook.] Scribn.) and switchgrass (*Panicum virgatum* L.). Primary cool-season species were Kentucky bluegrass (*Poa pratensis* L.), smooth bromegrass (*Bromus inermis* Leyss.), redtop (*Agrostis alba* L.), timothy (*Phleum pratense* L.) and various wheatgrasses (*Agropyron* spp.). Steers were housed in partially covered individual pens (6 × 9 m) with concrete floors and had continuous access to hay, water and iodized salt. Hay was fed each morning at 0700 after orts from the previous feeding were removed and weighed. Amount of hay offered daily equaled the previous day's consumption plus 20%. Supplements, fed immediately after all animals received hay, were consumed within 1 h of feeding.

Each of the four periods lasted 29 d. Seven days were allowed for diet adjustment. Hay intake was measured the following 14 d. Ruminal fluid samples were taken from cannulated steers on d 22 and 23. From d 25 through 29, total feces were collected from the cannulated steers. The intact steers remained on their respective supplements during d 22 and through 29; however, feed intake data were not included in the analyses.

Ruminal fluid samples were taken from cannulated steers 1 h prior to supplement feeding on d 22 and at 2-h intervals thereafter through d 23. On d 22, the 23-h sample also served as the –1 h sample for d 23. Ruminal contents were mixed prior to sampling. Upon removal from the rumen, pH of the sample was determined. Fluid strained from particles using four layers of cheesecloth was acidified (1 ml 20% H_2SO_4/50 ml ruminal fluid) and frozen at –10°C.

TABLE 2. CHEMICAL COMPOSITION OF HAY AND DAILY SUPPLEMENTS FED IN TRIAL 1

Item, %	Hay	Starch from corn, g/kg BW		
		0 (PS)[a]	2 (PLC)[a]	4 (PHC)[a]
CP	4.3	48.5	24.5	16.0
IVDMD[b]	49.2			
NDF	72.9	9.7	11.1	11.2
ADF	46.2	7.1	5.2	4.1
Lignin	6.2	1.7	1.2	1.2
Ash	11.2	8.0	4.2	3.0
AIA	8.2	.3	.7	.1

[a]PS = protein–no corn supplement; PLC = protein–low corn supplement; PHC = protein–high corn.

[b]In vitro DM digestibility.

Cannulated steers were fitted with fecal bags at 1800 on d 24. Bags were changed at 0600 on d 25 and at 8-h intervals through d 29. Upon removal, individual bags containing feces were weighed, with the weight of the bag subtracted to determine feces weight. After weighing, feces in each bag were mixed and a 10% aliquot was stored at 2°C until the end of the period. Equal amounts of feces (wet weight basis) from daily aliquots were mixed for each animal at the end of each period and a subsample was processed for analysis. Hay, orts and supplements were sampled daily from d 24 through 28. Ort samples were combined across days within treatment at the end of each period and subsampled. Samples of feces were dried at 60°C for 60 h. Samples of corn, hay and orts were dried at 60°C for 24 h. A representative sample of each also was dried at 100°C for 60 h to determine DM. Samples dried at 60°C were allowed to equilibrate at room temperature for 24 h, ground through a 2-mm screen in a Wiley mill and then through a 1-mm screen in a Udy cyclone mill. Samples were stored in airtight containers until analysis. During the intake portion of each study, daily samples of hay, orts and supplements were taken and combined after 7 d. Subsamples of each were dried at 100°C for 60 h to determine DM.

Trial 2. One hundred thirty-five crossbred 4 to 9-year old cows in good condition were randomized within age and used in a completely randomized design to determine the effect of supplemental energy and protein on performance of cows and calves while grazing Sandhills winter range or receiving grass hay. This study was conducted at the Gudmundsen Sandhills Laboratory near Whitman, Nebraska. Three supplement treatments were used with three replications of each treatment. Supplement treatments were ear corn to supply 1.16 kg TDN plus 127 g CP$\cdot$hd$^{-1}\cdot$d^{-1}, ear corn plus a protein supplement to supply 1.16 kg TDN plus 290 g CP$\cdot$hd$^{-1}\cdot$d^{-1} and protein supplement (without ear corn) to supply .72 kg TDN plus 290 g CP$\cdot$hd$^{-1}\cdot$d^{-1}. The protein supplement fed with ear corn was a commercially prepared, cubed, 32% natural-protein supplement containing soybean meal, cottonseed meal, dehydrated alfalfa meal, other plant protein products and appropriate minerals and vitamin A. The protein supplement fed without ear corn was a cubed, 40% natural-protein, supplement containing soybean meal and appropriate minerals and vitamin A prepared in the feedmill at the West Central Research and Extension Center. The study was conducted through three phases of the annual cycle: winter grazing, calving and summer grazing. Supplements were fed only during the first two phases.

Cows grazed native range during the winter phase (112 d) of the study. The site was predominately choppy sands and sands in excellent condition. Dominant grasses were sand bluestem (*Andropogon hallii* Hack.), little bluestem (*A. scoparius* Michx.), blue grama (*Bouteloua gracilis* [H.B.K.] Lag. ex Griffiths), hairy grama (*B. hirsuta* Lag.), prairie sandreed (*Calamovilfa longifolia* [Hook.] Scribn), sand lovegrass (*Eragrostis trichodes* [Nutt.] Wood) and switchgrass (*Panicum virgatum* L.). Leadplant (*Amorpha canescens* Pursh) was the predominant shrub, with lesser amounts of other grasses and forbs present. During two previous winters, similar range forage collected via esophageally fistulated steers contained 5.0% CP and 51% in vitro OM digestibility (Knott, 1983). Treatment groups were assigned randomly to one of nine pastures (approximately 44 ha each). Vegetative composition and condition of pastures were similar. Pastures had not been grazed the previous summer. Groups had continual access to a salt-dicalcium phosphate mixture (50:50). Supplements were fed on the ground 6 d/wk.

During the calving phase (60 d), cows were confined in .6-ha lots. Supplement treatments were continued during calving, with supplements fed in bunks. Cows had ad libitum access to a good-quality meadow grass hay (10% CP; 58% in vitro DM digestion [IVDMD]), water and the salt-dicalcium phosphate mixture used in the winter. Supplementation stopped at the beginning of the summer phase (May 7). During the summer, cows grazed together in a native grass pasture until weaning (Oct. 10).

Cow weights were recorded after 16 h without feed and water at the beginning of the trial (winter), at calving, at the beginning of the summer phase and at weaning. Calves were weighed within 12 h of birth, at the beginning of the summer phase and at weaning. Data from cows (and from their calves) that had not calved more than 20 d prior to the onset of the summer phase were excluded from the analysis of the weight for that time. Cows were examined for pregnancy by rectal palpation at weaning.

Analytical Procedures. Procedures outlined by AOAC (1975) were used to determine DM and ash of feed, fecal and ort samples and CP (Kjeldahl N × 6.25) of feed samples. All samples were analyzed for NDF, ADF and ADL using procedures described by Goering and Van Soest (1970). Hemicellulose (**HCL**) was expressed as the difference between NDF and ADF. Cellulose (**CEL**) was estimated as the weight of ADF lost in the ADL procedure prior to ashing. Determination of AIA in hay samples followed procedures outlined by Van Keulen and Young (1977). Hay samples were analyzed for IVDMD according to Tilley and Terry (1963). Starch values were taken from feed composition tables (Leonard and Martin, 1963).

Stored ruminal fluid samples were allowed to thaw overnight at room temperature. Samples were shaken vigorously after thawing to mix contents. The 50-ml samples were removed and centrifuged at 2,000 × *g* for 10 min. Ammonia N was determined on the supernatant fluid, using the phenol-hypochlorite procedure outlined by Broderick and Kang (1980).

Calculations and Data Analysis. Hay DM and OM digestion coefficients were determined by the method described by Sanson and Clanton (1989) assuming supplement digestibility was equal to calculated TDN values (75, 76 and 77% TDN for PS, PLC and PHC, respectively). Metabolizable energy intake of the hay in Trial 1 was estimated as 82% of DE (NRC, 1984). A DE value was calculated from the equation of Rittenhouse et al. (1971) where DE = .038 (% DM digestibility) + .18, using the DM digestibility values for the hay from each treatment. Total ME intake was estimated by adding the calculated ME intake value for the supplement [(TDN × 4.4) .82 = ME)] plus hay ME intake.

In Trial 2, calving interval was calculated for the 95 cows remaining in the herd during the following calving season. Calving interval was calculated by subtracting calving date during the trial from the subsequent calving date. Other cows were culled because of not rebreeding (16 hd) or due to age (24 hd).

Statistical procedures were those of SAS (1985). Intake and ruminal parameters in Trial 1 were analyzed by GLM procedures appropriate for a replicated latin square split-plot in time design. Day was considered the replicate for ruminal values and animals (four fistulated and four intact steers) served as replicates for the intake data. Reported values were pooled across time where there was no significant ($P > .05$) time × treatment interaction. When time × treatment interactions were significant, data were analyzed and are reported within time. Diet digestibility data were analyzed with a GLM model for a latin square treatment design. When treatment effects were significant ($P < .05$), orthogonal contrasts were examined to determine the effect of the average of supplementation treatments vs no supplement and within the supplement treatments to determine the linear and quadratic effects of corn content of supplements. When both linear and quadratic effects were significant ($P < .10$), only the quadratic contrast is presented. In Trial 2, body weights, body weight changes, ADG, birth dates, conception rate and calving interval were analyzed with a GLM model for a one-way analysis of variance. Conception rates were transformed to a logit (Cox, 1970) before analysis by GLM. Mean values were separated by least significant differences when a significant treatment effect was observed ($P < .05$).

Results

Trial 1. No treatment × day interaction ($P \geq .151$) was observed for intake data; thus, means were pooled across days (Table 3). A quadratic effect ($P \leq .001$) of level of supplemental corn was observed for forage intake. A 5% decrease in forage consumed occurred with the first increment of corn in the supplement, whereas the decrease was 17% between the first and second increment. Hay intake expressed as kilogram/day was higher ($P < .001$) for animals that received supplements than for those that received no supplement; however, steers fed PHC actually consumed less forage than steers fed NS. Addition of corn to the protein supplement also caused a quadratic ($P \leq .016$) effect on total diet DM intake. Animals receiving PS or PHC had the same mean total intake (10.6 $kg \cdot hd^{-1} \cdot d^{-1}$), whereas a mean intake level of 11.1 $kg \cdot hd^{-1} \cdot d^{-1}$ was observed when steers received PLC. This was an increase in dietary intake of 4.7%. Total diet DM intake was higher ($P = .001$) when steers received a supplement than when they received no supplement.

Hay digestibility was calculated assuming supplements had constant digestibility at NRC

TABLE 3. DAILY INTAKE OF LOW-QUALITY MEADOW HAY BY STEERS FED DIFFERENT SUPPLEMENTS

Intake	Starch from corn, g/kg BW 0 (PS)[a]	2 (PLC)[a]	4 (PHC)[a]	Control (NS)[a]	SE	Corn P	Control vs supplement P
DM							
Hay, kg	9.5	9.0	7.4	8.2	.1	<.001[b]	<.001
Hay, g/kg $BW^{.75}$	95.4	89.7	72.8	82.7	1.5	.003[b]	.056
Hay, % BW	2.1	2.0	1.6	1.8	.04	.012[b]	.154
Total, kg	10.6	11.1	10.6	8.2	.1	<.001[b]	<.001
Total, g/kg $BW^{.75}$	105.7	110.4	103.4	82.7	1.6	.004[b]	<.001
Total, % BW	2.3	2.4	2.2	1.8	.05	.016[b]	<.001
Digestible DM							
Hay, kg	5.2	4.9	3.8	4.1	.04	<.001[b]	<.001
Total, kg	5.4	5.3	4.4	4.1	.05	<.001[b]	<.001
Estimated ME							
Hay, Mcal	17.8	16.5	13.0	13.9	.14	<.001[b]	<.001
Total, Mcal	20.2	22.1	21.4	13.9	.16	<.001[b]	<.001

[a]PS = protein–no corn supplement; PLC = protein–low corn supplement; PHC = protein–high corn; NS = no supplement.
[b]Quadratic response.

(1988) levels. Hay digestible DM intake responded quadratically ($P < .001$) to level of corn in the supplement. An initial decrease of 6% was observed for the first level of corn and a further decrease of 21% was observed with further addition of corn. Although only a small difference in total digestible DM intake occurred between PS and PLC, PHC resulted in an 18% depression of total digestible DM intake. Hay and total DM intake was higher when animals received supplements compared with no supplement. Metabolizable energy intakes responded quadratically ($P < .001$) to increased level of corn. Hay ME intake was decreased by 7.3% when corn was included in the supplement and depressed an additional 9.2% when the level of corn increased. However, total diet ME intake was highest for PLC followed by PHC and lowest for PS. Mean total intake of ME was increased by 60% when supplement was fed compared to NS.

A quadratic effect ($P \leq .057$) was observed for DM and OM digestion due to supplemental corn (Table 4). Mean apparent DM digestion increased 4.5% from the PC to PLC treatment

TABLE 4. DIGESTION COEFFICIENTS FOR FORAGE AND DIETS OF STEERS FED LOW-QUALITY MEADOW HAY AND SUPPLEMENTED WITH DIFFERENT LEVELS OF PROTEIN AND ENERGY

Digestibility, %	Starch from corn, g/kg BW 0 (PS)[a]	2 (PLC)[a]	4 (PHC)[a]	Control (NS)[a]	SE	Corn P	Control vs protein P
Apparent DM	56.68	59.21	60.00	49.48	1.00	.057[b]	<.001
Apparent OM	60.20	62.82	64.27	54.36	.82	.013[b]	<.001
NDF	52.68	51.07	49.49	49.96	.70	.018[b]	.212
ADF	48.60	46.73	46.51	44.08	.91	.157[b]	.023
Hemicellulose	59.76	58.42	54.32	60.49	1.30	.025[b]	.093
Cellulose	68.62	71.32	67.78	67.79	2.65	TNS[d]	TNS[d]
Hay DM[e]	54.48	54.54	51.97	49.48	1.34	.237[b]	.036
Hay OM[e]	58.28	58.71	57.67	54.36	.93	.542[c]	.012

[a]PS = protein–no corn supplement; PLC = protein–low corn supplement; PHC = protein–high corn; NS = no supplement.
[b]Linear.
[c]Quadratic.
[d]Treatment effect not significant ($P > .10$).
[e]Calculated assuming supplement digestibility = TDN value.

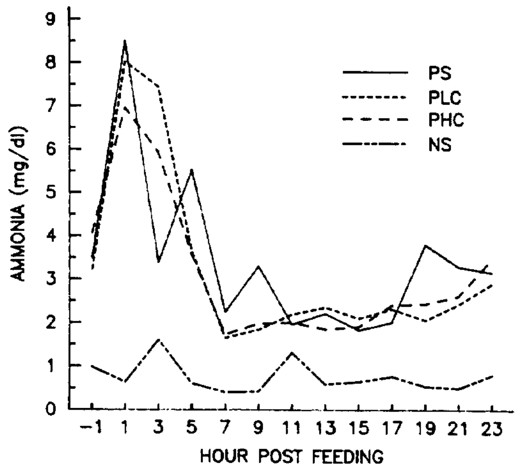

Figure 1. Ruminal ammonia of steers receiving different levels of supplemental corn.

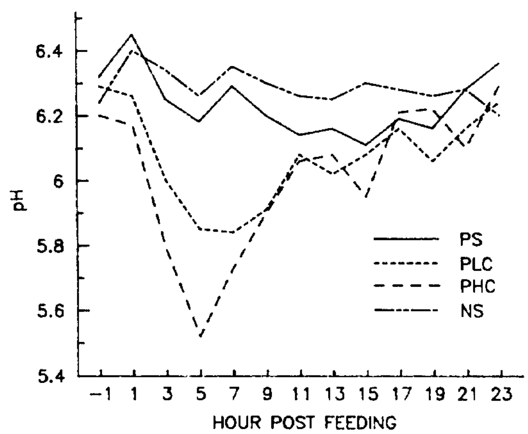

Figure 2. Ruminal pH of steers receiving different levels of supplemental corn.

and 1.3% from PLC to PHC treatment. Supplementation improved ($P \leq .001$) both DM and OM digestion compared with no supplement. Neutral detergent fiber digestion was decreased quadratically ($P = .018$) as level of corn in the supplement increased; however, averaged across supplements, supplementation did not improve ($P = .212$) NDF digestion compared with no supplement. Acid detergent fiber digestion was not different ($P = .157$) among corn supplements, but digestion of ADF was improved ($P = .023$) by supplementation compared with no supplement. A quadratic effect ($P = .025$) for HCL digestion was observed due to adding corn to the supplement. Digestion of HCL decreased 2% from PS to PLC treatment and an additional 7% from PLC to PHC treatment. Cellulose digestion was not affected by treatment ($P > .758$). Level of corn in the supplement did not affect ($P \geq .237$) hay DM or OM digestion, although supplementation did increase ($P \leq .036$) digestion of hay DM and OM.

Because of a treatment × hour interaction ($P \geq .100$), ruminal data are presented by hour. Adding corn to the supplement caused a quadratic effect ($P < .012$) on ruminal fluid ammonia at h –1, 1, 7, 17, 21 and 23 and a linear effect at h 3, 5, 13 and 15 (Figure 1). There was no effect ($P \geq .114$) at h 9, 11 and 19. In general, level of corn supplementation did not greatly affect ruminal ammonia. Supplementation increased ammonia levels at all hours compared with no supplement.

Ruminal fluid pH (Figure 2) responded in a quadratic manner ($P \leq .051$) at h 1, 3, 5, 7, 9, 13 and 15 and linearly ($P = .031$) at h 19 due to level of corn in the supplement. The major depression in pH was observed at h 1, 3, 5 and 7 for PLC and PHC treatments; the ruminal fluid pH dropped below 6 at h 3, 5, 7 and 9 for these treatments. Supplementation decreased ($P \leq .034$) ruminal fluid pH at h 1, 3, 5 and 7 compared with no supplementation.

Trial 2. Cows that received ear corn lost more weight during winter grazing than cows that received ear corn plus protein supplement (Table 5); both groups lost more weight than cows that received only protein supplement ($P < .001$). However, both groups that received ear corn gained more weight ($P < .001$) than the protein-supplemented cows (no ear corn) during the calving phase when grass hay was fed. Both groups of cows fed ear corn gained weight and the group that received only protein supplement lost weight during the calving phase. Cows that received only protein supplement gained 16 kg during the summer phase, whereas those that received ear corn gained 46 kg ($P < .001$). During the summer phase, even though no supplements were fed, those that had received only ear corn earlier gained faster than those that received ear corn and protein supplement earlier. Body weight changes during the entire trial were similar for

TABLE 5. WEIGHT CHANGES OF COWS SUPPLEMENTED WITH EAR CORN AND(OR) PROTEIN SUPPLEMENT (TRIAL 2)

Item	Ear corn	Ear corn + protein	Protein	SE	*P*
Initial wt, kg	528	523	525	7	TNS[a]
Wt gain, kg					
Winter	-54^b	-18^c	6^d	3	.001
Calving	5^b	1^b	-20^c	3	.001
Summer	46^b	23^c	16^d	4	.001
Trial	-8^b	4^c	3^c	3	.010

[a]Treatment effect not significant ($P > .05$).

[b,c,d]Row means with different superscripts are different.

both groups that received protein supplement (4 and 3 kg), whereas cows that received only ear corn lost 8 kg (P = .01)

Cows that received only protein supplement calved later (P = .034) than those that received ear corn (Table 6), although mean differences were only 3 or 4 d. There was no effect (P = .713) of treatment on birth weight. Supplementation with only ear corn decreased ($P \leq .042$) calf weight and calf ADG from birth to the end of the calving phase compared to those that received protein supplement; however, weaning weights were similar among all treatments (P = .115). Calves whose dams received protein supplement only were younger (P = .042) at weaning due to the later mean calving date for this treatment.

Conception rate was not affected (P = .705) among treatments (87, 91 and 91% for ear corn, ear corn plus protein and protein, respectively). Conception date following supplementation and subsequent calving date of the cows remaining in the herd also were not affected ($P \geq .700$) by treatment.

Discussion

The decrease in forage intake by steers in Trial 1 as level of corn was increased in the supplement agrees with reports by Elliott (1967a) working with cattle and with Fontenot et al. (1955) and Elliott (1967b) with sheep. In our study, the feeding level of PLC supplied .26% of BW of corn; feeding PHC supplied .52% of BW of corn. Increasing level of corn from 0 to .26% of BW resulted in a decrease in hay intake by 5%. Increasing the level of corn intake from .26 to .52% of BW resulted in a 17% depression in hay intake. In a previous study, Sanson and Clanton (1989) fed whole corn at .25% or .50% of BW to steers that received a low-protein hay. The .25% lowered intake 3% and the .50% lowered intake 20%. This would indicate that there is not an interaction between protein and energy in the supplement, but that even when the protein requirement of the animal is met, supplementing low-quality forage with corn will decrease forage intake.

These data suggest that when protein is adequate in the diet, high levels of corn feeding (52% of BW) will depress fiber digestion. Similar results have been reported by Chase and Hibberd (1987). The quadratic effect observed indicates that forage digestibility is not affected at low levels of corn feeding. This same observation was made by Sanson and Clanton (1989).

Ruminal fluid pH and ammonia levels at h 1, 3, 5 and 7 post-supplementation suggest that fermentation of readily available carbohydrates increased as level of corn in the diet increased. Ruminal fluid ammonia levels of PS, PLC and PHC steers were above the recommended levels for maximum microbial growth (2 to 5 mg/dl) suggested by Satter and Slyter (1974), so fiber digestion should not have been depressed by low ammonia levels. However, ruminal fluid pH of steers receiving PLC and PHC was less than 6.0 at h 3, 5, 7, 9, 11, 13 and 15. A similar trend was observed by Mould and Ørskov (1983) with grain supplementation. Depression in cellulolytic enzyme activity (Smith et al., 1973) and numbers of cellulolytic bacteria (Russell and Dombrowski, 1980) have been reported when pH was below 6.0. However, Chase et al. (1988) did not observe a difference in cellulose digestion when pH was maintained above 6.4 compared to a pH between 5.8 to 6.2. Cellulose digestibility was not altered in the present study, although digestibilities of NDF and HCl

TABLE 6. PERFORMANCE OF CALVES WHOSE DAMS RECEIVED EAR CORN AND(OR) PROTEIN SUPPLEMENTATION (TRIAL 2)

Item	Ear corn	Ear corn + protein	Protein	SE	*P*
Birth date	Mar. 29[a]	Mar. 31[ab]	Apr. 3[b]	1.4	.034
Birth wt, kg	44	44	44	1	TNS[c]
Spring wt, kg	72[a]	78[b]	78[b]	2	.028
Spring ADG, kg	.74[a]	.88[b]	.87[b]	.03	.042
Wean wt, kg	224	230	225	4	TNS[c]
Wean age, day	194[a]	193[ab]	189[b]	1.5	.042
Wean ADG, kg	.93	.96	.96	.01	TNS[c]

[a,b]Row means without a common letter in their superscripts differ.

[c]Treatment effect not significant ($P > .05$).

were depressed. The suppression of ruminal fluid pH at higher levels of corn feeding did not affect hay DM digestion.

In Trial 2, cows fed ear corn lost 10% of their BW during the winter phase, indicating the animals were in a severe negative nutrient balance. The assumption that lack of energy contributed to poorer performance was not supported by the fact that cows fed ear corn plus a protein supplement did not perform as well as those fed only protein supplement. Evidently, factors other than protein deficiency were involved. Data from Trial 1 suggest that forage intake and fiber digestibility were decreased in cows fed ear corn.

Weight changes of the cows during the calving season would indicate that corn did not have an adverse effect on the utilization of the medium-quality hay fed during that time. Cows that received ear corn gained 5 kg and cows that received ear corn plus protein supplement gained 1 kg during the calving season, although they experienced the loss of weight due to calving. Others have reported improved performance with cattle and sheep fed medium-quality (Allden, 1959; Allden and Tudor, 1976) or high-quality forages (Lake et al., 1974; Coleman et al., 1976; Denham, 1977) and supplemented with grain. Calves from the cows supplemented with ear corn gained less weight from birth to time of going to summer pasture than did calves from cows fed the supplements with protein; this implies that the higher gain of BW in cows receiving only ear corn was at the expense of milk production. There were no differences in weaning weight of the three groups of calves. Ansotegui (1986) found that calves will increase forage intake to compensate for reduced milk intake and will have DE intakes similar to those of calves receiving more milk. If milk production was lower in cows receiving ear corn in this study, their calves may have compensated by increasing forage intake.

The reproductive performance of the cows in the different treatment groups was not different ($P > .05$). Wiltbank et al. (1962) reported that cows that lost 10% of their BW prior to calving had conception rates similar to those of contemporaries that gained 6% of their BW prior to calving providing that the plane of nutrition was increased post-calving.

Implications

When the level of supplemental corn was increased from .26% of BW to .52% of BW, a 17% decrease in intake and 21% decrease in digestibility of low-quality forage was observed. Cows grazing native range lost more weight when supplemented with a protein supplement plus ear corn than with a protein supplement alone. Addition of corn to supplements for cattle fed low-quality forages should be done in moderation in order to prevent a suppression of intake and digestibility of the forage, which subsequently decreases animal performance.

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