Condensed Molasses Solubles and Corn Steep Liquor As Protein Supplements for Range Cows

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Story in Brief

Corn steep liquor (CSL) and condensed molasses solubles (CMS) were compared in two trials to cottonseed meal as protein supplements for wintering dry, pregnant Hereford cows on native range. In trial 1, 48 cows were assigned to four protein treatments: negative control, positive control, CMS and CSL that furnished .30, .64, .57 and .66 lb supplemental crude protein per head per day, respectively. Cows were group-fed 6 days per week. Weight losses for 112 days were greatest for negative control and CMS and least for positive control and CSL. Rumen ammonia-N levels at 1-and 4-hr postfeeding were higher ($P<.05$) for CMS and CSL than for either control. In trial 2, 60 cows were individually fed 6 days each week four protein supplements: negative control, positive control, CSM and CSL to provide .18, .51, .40 and .51 lb crude protein per day for 84 days, respectively. Weight losses after 56 and 84 days of supplementation and condition losses after 84 days were lower ($P<.01$) for cows fed the positive control and CSL than for the negative control and CMS. Weight losses for the negative control, positive control, CMS and CSL were 44.0, 11.0, 44.0 and 14.0 lb after 56 days and 57.0, 11.0, 51.0 and 22.0 lb after 84 days, respectively. Condition losses were .96, .33, .90 and .28, respectively, after 84 days. Rumen ammonia levels were higher at 1-and 4-hr postfeeding for cows fed both liquid supplements than for controls. The CSL supplement contained 72 percent of the crude protein as amino acids compared to 39 percent for CSL. Tungstic acid precipitable protein was much higher in CSL (35 percent) than in CMS (12 percent). Corn steep liquor appeared to be about equal to cottonseed meal for wintering dry, pregnant cows on native range.

Introduction

Liquid supplements contain a variety of ingredients, many of which are by-products from the manufacture of foods, alcoholic beverages, glutamic acid and other products. The increased use of liquid by-products as feed ingredients has been caused by several factors, among which are the high cost of molasses, poor results with urea-molasses for cattle consuming low quality roughage and environmental regulations prohibiting the dumping of wastes.

Little is known about the composition of many liquid feed ingredients or their usefulness as protein sources to ruminants fed low quality roughage. If these ingredients have nitrogenous fractions that are mostly ammonia, urea or ammonium compounds, they will likely perform no better than urea-molasses mixes. However, if their nitrogen fractions are high in amino acids, peptides and proteins of plant or microbial origin, some by-products could be acceptable protein sources for ruminants.

Two of the most common by-products in liquid supplements are condensed fermented corn extractives, commonly referred to as corn steep liquor (CSL) and condensed molasses solubles (CMS). Corn steep liquor is obtained during the wet milling of corn and contains most of the soluble proteins of corn. Condensed molasses solubles is the residue from molasses that has been used in various fermentations to produce glutamic acid, citric acid, ethanol and other products.

The objective of this research was to evaluate CSL and CMS as protein sources for beef cows grazing dormant native range.

Materials and Methods

Trial 1.

Forty-eight dry, pregnant Hereford cows were allotted by weight to four supplemental protein treatments (Table 1). Treatments were: negative control, .30 lb crude protein (CP) per day; positive control, .62 lb CP per day; CMS, .62 lb CP per day; and CSL, .62 lb per day. Each treatment was replicated twice with each replicate grazing a pasture of about 80 acres. Forage consisted of native tallgrass with little bluestem, big bluestem, switchgrass and Indiangrass. All supplements were calculated to be approximately isocaloric and to provide equal amounts of phosphorus and potassium.

Initially cows were offered liquid supplements ad libitum in lick tanks filled twice weekly. However, it was apparent after 1 week that the liquid supplements were very palatable and that all supplement was consumed within a few hours after the tanks were filled. Thereafter, supplements were fed 6 days per week with dry supplements fed in metal troughs and liquid supplements fed in lick feeders made from metal drums.

Table 1. Percent composition of supplements fed in trial 1

	Treatments			
Ingredient	Negative control	Positive control	Condensed molasses solubles (CMS)	Corn steep liquor (CSL)
Cottonseed meal	7.2	40.8		
Corn, ground	82.5	51.3		
Dicalcium phosphate	6.9	5.0		
Salt	2.2	2.2		
Potassium chloride	1.0	.5		
Trace mineral premix	.1	.1	.1	.1
Vitamin A (30,000 IU/g)	.1	.1	.3	.3
Cane molasses			39.1	41.6
CMS			55.0	
CSL				55.0
Ammonium polyphosphate			3.5	3.0
Phosphoric acid			2.0	
Analysis (as fed)				
Dry matter, %	90.1	90.0	66.0	61.0
Crude protein, %	10.1	20.2	14.5	16.2

Liquid supplements were mixed at a commercial facility and stored in 55 gal steel drums until feeding. Dry supplements were manufactured at the Oklahoma State University feedmill.

Cows were weighed after overnight withdrawal from feed and water at the beginning of the study and at 28-day intervals thereafter. The trial was conducted for 112 days, from November 22, 1978, to March 3, 1979. One animal from each CSL replicate refused to eat supplement and was removed from the study; both cows were extremely timid and refused to approach the feeders with others present. One cow was removed from the positive control because she aborted, and one cow was removed from the negative control because she calved during the study.

In mid-January cows from one replicate of each treatment were fed their supplements individually. Rumen fluid samples were withdrawn via stomach tube at 1 hour and 4 hours after feeding for rumen ammonia analyses. Microbial action was stopped in rumen fluid by adding 5 g of meta-phosphoric acid per 50 ml of rumen fluid. Samples were then frozen for subsequent rumen ammonia analysis.

Trial 2

Sixty dry, pregnant Hereford cows were allotted by weight to four supplemental protein treatments (Table 2). Treatments were: negative control (8 percent CP), positive control (24 percent CP), CMS (16 percent CP) and CSL (18 percent CP). Liquid supplements were again mixed at a commercial facility but were delivered and stored in bulk rather than drums as in trial 1.

Table 2. Percent composition of supplements fed in trial 2

	Treatments			
Ingredient	Negative control	Positive control	Condensed molasses solubles (CMS)	Corn steep liquor (CSL)
Cottonseed meal		48.0		
Corn, ground	89.0	44.0		
Dicalcium phosphate	6.8	4.8		
Salt	2.0	2.0		
Potassium chloride	2.0	1.0		
Trace mineral mix	.1	.1	.1	.1
Vitamin A (30,000 IU/g)	.1	.1	.1	.1
CMS			71.1	
CSL				71.1
Water			7.1	.7
Cane molasses			17.2	25.5
Sulfuric acid			.5	.5
Phosphoric acid			3.9	2.0
Analysis (as-fed)				
Dry matter, %	90.3	91.2	59.2	54.4
Crude protein, %	8.4	23.0	15.9	17.9
pH			4.1	4.1

Cows were gathered at 8 a.m., 6 days each week and fed their supplements individually. Cows on all treatments grazed a common pasture with ample standing tallgrass forage as described in trial 1. The trial lasted 84 days, from December 7, 1979, to February 29, 1980. Large round bales of wheat straw were offered free choice on days when snow or ice covered the grass.

During the first 56 days of the study, the positive control, CMS and CSL supplements were fed in isonitrogenous amounts based on bi-weekly analysis of supplements. The negative control was fed to provide one-third the CP of the positive control. At these levels of consumption, all supplements were formulated to provide equal amounts of supplemental energy. During the last 28 days of the study, supplement levels were increased to maintain weight of the positive control cows. However, CMS was less palatable than the other supplements, so cows fed CMS were allowed to consume all they would in 45 minutes.

Weights were taken, and rumen fluid was sampled from 10 cows on each treatment as described in trial 1. Cows were visually scored for condition at the beginning and end of the trial based on a rank of 1 = very thin to 10 = very fat. Supplements were sampled weekly for analysis.

Results and Discussion

Trial 1.

Supplements were readily consumed by all cows (Table 3) except two that refused to approach the lick feeders and thus were removed from the study. The liquid supplements were palatable, evidenced by the fact that during the first week of

Table 3. Weights, weight changes and rumen ammonia levels for cows in trial 1

	Treatments			
Item	Negative control	Positive control	CMS	CSL
Number of cows				
Replication 1	6	5	6	5
Replication 2	5	6	6	5
Initial cow wt				
Replication 1	922	891	919	930
Replication 2	946	922	942	917
Wt change, 112 days				
Replication 1	16.0	− 7.0	−38.1	5.1
Replication 2	−83.8	−35.9	−41.0	14.9
Supp consumption, kg/day	1.41	1.41	1.82	1.82
Crude protein intake	.30	.64	.57	.66
Rumen Ammonia-N mg/dl				
1 hr postfeeding	1.78^c	1.48^c	22.90^a	13.70^b
4 hr postfeeding	$.46^b$	2.28^b	8.84^a	8.88^a

[a,b,c]Means with different superscript letters differ significantly ($P<.05$).

the study cows on CSL and CMS consumed a 3-day allowance (over 12 lb per head) within 4 hours. Apparently, ammonia toxicity is not a major problem with CSL- or CMS- based supplements. A similar intake of a urea-molasses supplement with 90 percent of the crude protein equivalent from urea would have provided about .30 grams/lb body weight of urea to a 950-lb cow and probably would have been toxic.

Cows fed CSL gained weight during the 112-day trial, and their performance slightly exceeded that of positive control cows. Positive control cows tended to lose less weight than negative control cows. Weight losses of CMS cows tended to be between the positive and negative controls.

Rumen ammonia-N levels at 1-hour postfeeding were highest ($P<.05$) for the liquid supplements and lowest for control supplements. CSM produced higher ($P<.05$) levels than did CSL. Ammonia-N concentrations at 4-hour postfeeding were similar for CMS and CSL, with both liquid supplements producing more rumen ammonia ($P<.05$) than the control supplements.

Trial 2.

Cows grazing a single pasture were individually fed to measure supplement intake of each animal and to eliminate the pasture effects encountered in trial 1. Sulfuric acid, a common intake limiter, was added to both liquid supplements (Table 2) at the manufacturing plant; and as a result, they were not as palatable as in trial 1. Three cows refused to eat the CMS supplement and were switched with two cows from the positive control and one cow from the negative control that would readily consume CMS. All CSL supplement and most of the CMS was readily consumed at the levels offered for the first 56 days of the trial (Table 4). When the supplement levels were increased during the final 28 days of the trial to maintain weight of the positive control cows, all but one cow on CSL consumed the increased supplement. Several cows fed CMS refused to consume a level that was isonitrogenous to the positive control. In addition to the presence of sulfuric acid, reduced supplement intake in trial 2 compared to trial 1 could be attributed to the absence of feeding competition and to the lower molasses content of the liquid supplements.

The negative controls lost more ($P<.01$) weight than the positive controls after 56 and 84 days. Cows fed CSL lost 8.0 lb during the final 28 days compared to no weight loss for the positive controls; however, one-half the weight loss in the CSL group occurred in one cow that consumed only 65 percent of her supplement during the last 28 days. Weight losses for the negative control and CMS groups were almost identical throughout the study. Condition score changes followed weight change patterns, with negative control and CMS cows losing more ($P<.01$) condition during the trial than positive control or CSL cows.

Rumen ammonia-N concentrations for CMS and CSL were similar at 1-hour postfeeding but were higher ($P<.05$) for CSL than CMS at 4 hours. Both liquid supplements produced higher ($P<.05$) rumen ammonia-N levels than the control supplements at both sampling times.

Weight changes for cows fed CSL were similar to those of cows fed the cottonseed meal-based positive control supplements in both trials, indicating CSL is an effective protein source for cows on dormant range grass. Conversely, the performance of cows on CMS was about equal to that of cows fed the negative control supplements in both trials, suggesting CMS is a poorly utilized protein source for cows on low quality forage.

A detailed analysis of the nitrogen fractions in the CMS and CSL supplements fed in trial 2 is shown in Table 5 and provides some explanation for the perform-

Table 4. Mean weights, weight changes and rumen ammonia levels for cows in trial 2

Item	Negative control	Positive control	Condensed molasses solubles (CMS)	Corn steep liquor (CSL)
Number of cows	15	15	15	15
Initial cow wt	895	895	915	920
Wt change, 56 days	-44.0^{b}	-11.0^{a}	-44.0^{b}	-14.0^{a}
Last 28 days	−13.0	0.0	−11.0	− 7.9
Total, 84 days	-57.0^{b}	-11.0^{a}	-55.0^{b}	-22.0^{a}
Condition score, initial	5.47	5.95	5.78	5.64
Condition score change, 84 days	$-.96^{b}$	$-.33^{a}$	$-.90^{b}$	$-.28^{a}$
Supplement consumption, lb/day				
First 56 days	1.7	1.7	2.2	2.4
Last 28 days	2.2	2.2	2.5	2.8
Total 84 days	1.9	1.9	2.3	2.6
Crude protein intake, lb/day				
First 56 days	.13	.40	.35	.44
Last 28 days	.18	.51	.40	.51
Total 84 days	.15	.44	.37	.46
Rumen Ammonia-N, mg/dl				
1 hr postfeeding	6.13^{b}	6.79^{b}	21.63^{a}	22.68^{a}
4 hr postfeeding	3.89^{c}	5.11^{c}	9.13^{b}	14.64^{a}

[a,b,c]Means with different superscript letters differ significantly ($P<.05$).

ance differences. Although the analyses are of the complete supplements rather than of CSL and CMS alone, they should represent these ingredients since the CP of molasses is low, and molasses made up small and similar proportions (17.2 and 25.5 percent) of the CMS and CSL supplements, respectively. Amino acid analysis of unhydrolyzed samples of each supplement indicate the concentrations of free amino acids, while analysis after hydrolysis indicates total amino acids including those in peptides and proteins.

Corn steep liquor contained 72.5 percent of the CP as amino acids compared to 39.3 percent for CMS. Subtracting free amino acids (unhydrolyzed) from total amino acids (hydrolyzed) shows that CSL contained about twice the level of amino acids in the form of peptides and proteins as CMS. Tungstic acid precipitable protein was much higher in CSL (35 percent) than in CMS (12 percent). Ammonia-N contributed 35.3 percent of the CP in CMS compared to 6.3 percent of the CP in CSL.

Table 5. Analysis of liquid supplements fed in trial 2

Item	CMS		CSL	
	Hydrolyzed	Unhydrolyzed	Hydrolyzed	Unhydrolyzed
Amino acids, % of dry matter				
Aspartic acid	.64	.02	1.74	.47
Thereonine	.17	.08	.91	.29
Serine	.22	—	.99	.51
Glutamic acid	5.65	2.12	4.28	.57
Proline	.17	—	3.00	1.10
Glycine	.47	.06	1.72	.32
Alanine	.88	.49	1.67	.87
Cystine	.16	—	.64	—
Valine	.35	.08	1.23	.51
Methionine	.17	.01	.34	.25
Isoleucine	.21	.02	.74	.29
Leucine	.28	.03	2.85	1.14
Tyrosine	.21	.10	.43	—
Phenylalanine	.10	.05	.80	.56
Histidine	.06	—	.88	.18
Lysine	.14	.02	.80	.41
Arginine	.12	—	.52	—
Total amino acids, % of dry matter	10.00	3.08	23.54	7.79
Crude protein, % of dry matter	25.4		32.5	
Composition (%) of crude protein,				
Ammonia-N	35.3		6.3	
Free amino acids[a]	12.1		24.0	
Peptide and protein amino acids[b]	27.2		48.5	
Tungstic acid precipitable protein	12.0		35.0	

[a]Calculated from unhydrolyzed sample.
[b]Calculated from hydrolyzed sample.

Other research has shown that amino acids are utilized by rumen bacteria and that rumen microbial protein yield can be increased by adding amino acids to a diet containing urea as the sole nitrogen source. Amino acids are also converted to volatile fatty acids by rumen bacteria and have been shown to stimulate rumen cellulolytic activity. An Ohio study showed that corn steep liquor significantly increased crude fiber, cellulose and dry matter digestibilities in lambs when added to a 50 percent roughage ration.

Results of this research indicate tht liquid supplement ingredients must be evaluated for type as well as amount of NPN.