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Effect of Fiber Level in Finishing Diets on Diet Digestibility and Corn Silage Impact on Bacterial Crude Protein Production

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Effect of Fiber Level in Finishing Diets on Diet Digestibility and Corn Silage Impact on Bacterial Crude Protein Production

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Daily bacterial crude protein production was greater when higher levels of dietary fiber were included in a finishing diet.

Summary

Two metabolism trials evaluated the impact of dietary fiber source, level, and digestibility on daily production of bacterial crude protein. In the first trial evaluating corn silage, digestibility was unaffected while daily bacterial crude protein production estimated from urinary allantoin excretion tended to be higher as corn silage replaced corn. In the second trial digestibility was significantly lower for the finishing diets containing higher levels of dietary corn bran.

Introduction

Increasing the fiber level of a beef finishing diet has the potential to increase bacterial crude protein (BCP) production due to an efficiency gain associated with effective neutral detergent fiber (eNDF) and rumen pH. Past research has demonstrated a good relationship between urinary allantoin excretion and duodenal flow of purines for measuring bacterial crude protein (BCP) production for beef cattle growing diets (*2001 Nebraska Beef Report*, pp. 115-116). However it is unclear as to how BCP levels are affected when the percentage of fiber in finishing diets is altered, or how digestibility of the diet affects BCP production. Therefore, it is important to understand what the impacts of source, level, or digestibility of fiber have on BCP production. In addition, effects of adding fiber to the diet on the carbon to nitrogen ratio in manure, and the relationship between diet digestibility and nitrogen loss from manure are important. Therefore the objectives of this research were: 1) to determine effects of increasing dietary corn silage and corn bran on digestibility, and 2) to evaluate how BCP production is affected when dietary corn silage is increased in typical corn-based feedlot diets.

Procedure

Six crossbred steers (1150 lb) were fitted with ruminal and duodenal cannulae and used in a replicated 3x3 Latin square digestibility trial. In Experiment 1, steers were randomly assigned to one of three treatments. Treatments were: 1) 15% corn silage and dry-rolled corn, 2) 30% corn silage with a dry-rolled/high-moisture corn mix, and 3) 45% corn silage and high-moisture corn (Table 1). Diets were formulated similar previous nutrient balance experiments in the feedlot (*2000 Nebraska Beef Report,* pp. 68-71). However, 1.5% urea was included to ensure adequate DIP for optimum BCP production. Steers were individually fed using continuous feeders with feed offered every two hours. The trial consisted of three, 14-day periods with seven days as adaptation, days eight-nine as rumen pH/VFA sampling, and days 10-14 as total urine and fecal collection. On days 10-14 total urine was collected by abdominal funnels attached to a vacuum pump; DM digestibility was determined by total fecal collection and using Cr_2O_3 as a

Table 1. Diet composition (% of DM) for Experiments 1 and 2.

	Experiment 1			[a] Experiment 2 [b]		
Ingredient	15CS	30CS	45CS	0bran	15bran	30bran
Corn silage	15	30	45	15	15	15
Corn bran	0	0	0	0	15	30
Dry-rolled corn	70	30	0	75	60	45
High-moisture corn	10	35	50	0	0	0
Molasses	0	0	0	5	5	5
Supplement	5	5	5	5	5	5
Urea	1.50	1.50	1.50	1.50	1.50	1.50
Limestone	1.30	1.20	1.10	1.45	1.42	1.39
Pot. chloride	0.67	0.45	0.23	0.46	0.46	0.46
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Tallow	0.10	0.10	0.10	0.10	0.10	0.10
Cr_2O_3	0.25	0.25	0.25	0.25	0.25	0.25
Trace Mineral	0.03	0.03	0.03	0.03	0.03	0.03
Vitamin ADE	0.01	0.01	0.01	0.01	0.01	0.01
Rumensin-80	0.016	0.016	0.016	0.017	0.017	0.017
Tylan-40	0.013	0.013	0.013	0.013	0.013	0.013
NE_m Mcal/lb[c]	0.96	0.92	0.88	0.93	0.90	0.87
NE_g Mcal/lb[c]	0.65	0.63	0.60	0.63	0.60	0.58

[a] 15CS is 15% corn silage diet, 30CS is 30% corn silage diet, 45CS is 45% corn silage diet.
[b] 0bran is 0 corn bran in diet, 15bran is 15% corn bran in diet, 30bran is 30% corn bran in diet.
[c] NE values calculated using tabular values for ingredients.

marker. Following collection of rumen samples, pH was recorded immediately and samples were frozen. Feces was collected daily, weighed and one aliquot frozen and subsequently freeze-dried. Another aliquot was dried in a 60°C forced air oven for DM determination.

In Experiment 2, the same six crossbred steers were used in a similar replicated 3x3 Latin square digestibility trial, and were randomly assigned to one of three treatments. Treatments were: 1) no bran, (0bran), 2) 15% bran (15bran), and 3) 30% (30bran) in the diet (Table 1). Diets were similar to previous nutrient balance feedlot research (*2002 Nebraska Beef Report*, pp. 54-57). The experiment consisted of three 14-day periods, with days one-seven as adaptation, days eight-nine as rumen pH/VFA sampling, and days 10-14 as total fecal collection. Total urine was not measured in Experiment 2, and DM and OM digestibilities were estimated only by the chromium marker method, otherwise sampling procedures were the same as in Experiment 1.

In Experiment 1 BCP production was calculated through the use of a derived equation. Determination of BCP from urinary allantoin excretion was determined with the following equation:

$Ma=(Ea - (.385 \times Wt^{.75}))/.850$

$BCP\ (g/d) = ((Ma/.85) * 70 * 6.25) / (.116 * .830 * 1000)$

Where: Ma = allantoin that originates from microbes (mmol/d);
Ea = allantoin excreted by the animal (mmol/d);
0.385 = mmol of allantoin that originate from 1 kg of metabolic body wt;
0.850 = the proportion absorbed allantoin excreted in the urine;
0.850 = the proportion of purine derivatives that are allantoin;
70.0 = g of N / mol of purine;
6.25 = CP conversion factor;
0.116 = purine N : microbial N ratio;
0.830 = intestinal digestibility of purines.

Urinary allantoin excretion was measured by the Rimini-Schryver reaction. The results of the BCP production based on allantoin excretion were compared to NRC prediction for BCP production (Table 4). Using the NRC calculations, we predicted BCP by two different methods. The first method involved inputs corrected for DMI and eNDF to match measured pH in Experiment 1. The second method used actual DMI, but allowed the NRC to predict rumen pH from the eNDF of ingredients. Corn silage NDF was 45% of DM and eNDF was 60% of NDF. Both high-moisture corn and dry-rolled corn were 10% NDF but 0% eNDF.

Results

Experiment 1

Increasing corn silage from 15% to 45% of dietary DM in a finishing diet resulted in a linear increase ($P < 0.01$) in average pH, but was more variable as indicated by a linear increase in pH variance ($P < 0.03$). The pH variance was calculated as total across day variability. Mean rumen pH for all treatments was less than 6.0 (Table 2). No differences ($P > 0.19$) in DMI for all three silage levels were observed, suggesting little prevalence of sub-acute acidosis. Surprisingly, no differences were observed in DM digestibility or OM digestibility, which may have been a result of cattle being fed smaller amounts every two hours rather than a typical twice a day feeding. Comparing total fecal collection to chromic oxide marker, values appear to be slightly lower for DM and OM digestibility with the chromic oxide method. However, the values for DM and OM excretion appear to be consistent between methods.

In the corn silage experiment, urinary allantoin increased (Linear $P < 0.0001$) with increasing level of corn silage (Table 4). Bacterial crude protein levels predicted from urinary allantoin responded similar to urinary allantoin. The 45% corn silage diet produced higher BCP levels than the 15% and 30% corn silage diets. Increasing the level of corn silage in the diet has the potential to increase microbial efficiency which is associated with a increased rumen pH, this in turn can result in a greater level of BCP production. As corn silage increased in the diet, high-moisture corn replaced dry-rolled corn. Adding high-moisture corn may increase BCP production because more starch fermentation occurs in the rumen compared to dry-rolled corn. Therefore, BCP production with the higher silage diets may be partially attributable to the high-moisture corn.

As with any prediction method there are concerns with using urinary allantoin excretion to predict BCP. Allantoin is cleared by the kidneys at a rapid rate after the hepatic oxidation of purines. Despite this rapid clearance, there are some other intermediate products (xanthine and uric acid) associated with the

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Table 2. Rumen pH, dry matter, and organic matter data (Experiment 1).

Item[a]	15CS	30CS	45CS	SE	Linear	Quad
pH 5.78	5.85	5.99	.07	.01	.55	
pH var[b]	.167	.179	.240	.02	.03	.32
DMI	24.5	25.2	23.5	.64	.31	.19
OMI	23.4	23.9	22.3	.60	.26	.19
Total Fecal Collection						
DM excretion lb/d	5.0	5.3	4.7	.34	.40	.19
DM digestibility %	80.9	79.1	79.3	1.10	.31	.43
OM excretion lb/d	4.6	4.7	4.2	.34	.26	.28
OM digestibility %	81.5	80.3	80.5	1.21	.55	.61
Chromium Marker Method						
DM excretion lbs/day	5.3	6.1	5.2	.33	.98	.07
DM digestibility %	78.5	75.7	76.9	1.33	.44	.27
OM excretion lbs/day	4.8	5.5	4.6	.31	.75	.10
OM digestibility %	79.3	77.2	79.0	1.32	.87	.26

[a]15CS is 15% corn silage diet, 30CS is 30% corn silage diet, 45CS is 45% corn silage diet.
[b]Total across day rumen pH variability.

oxidative process of purines that can be passed by the urine. However, they are a small fraction of the total purine oxidation process and were, therefore, not analyzed in these trials.

Experiment 2

Dry matter intake, as well as, OMI were not affected by dietary treatment (Table 3). However according to the chromium marker concentration in the feces, DM digestibility decreased linearly (P = 0.05) as corn bran increased from 0% to 30% of the finishing diet DM. Similar to DM digestibility, OM digestibility decreased linearly (P = 0.05) from 77.3 to 73.1% of OM intake. Rumen pH, although not a significant (P = 0.16) linear increase, was numerically greater for 15% and 30% corn bran diets than for 0% corn bran diet. These cattle were on automatic feeders with feed offered every two hours. Feeding in this manner probably decreases the impact that bran may have on rumen pH.

Our daily BCP prediction from urinary allantoin excretion in Experiment 1 suggest that daily BCP production increases as dietary fiber level increases (Table 4). However, the BCP predictions from urinary allantoin excretion are lower than the values predicted by the NRC calculations. When eNDF in the NRC model is adjusted to measured pH in this study, the range in BCP production was 64 g. This difference between 45% corn silage and 15% corn silage may be higher in feedlot situations. Steers in this experiment were fed every two hours which may minimize the impact of increasing eNDF with corn silage. When the NRC model was allowed to predict BCP by using eNDF of ingredients, increasing corn silage from 15% to 45% resulted in a larger increase in BCP production (229 g/d). Furthermore, both allantoin and NRC prediction methods of BCP suggest that increasing dietary corn silage in finishing diets increases BCP.

Table 3. Rumen pH, DM and OM digestibilities (Experiment 2).

Item[a]	15CS	30CS	45CS	SE	Linear	Quad
pH 5.71	5.83	5.85	.11	.16	.53	
pH var[b]	0.23	0.25	0.20	.04	.37	.28
DMI	21.3	22.2	21.3	.23	.81	.23
OMI	20.3	21.1	20.2	.22	.87	.75
Total Fecal Collection						
DM digestibility %	75.75	74.26	71.70	1.48	.05	.74
OM digestibility %	77.27	75.86	73.13	1.56	.06	.69

[a]0bran is 0 corn bran in diet, 15bran is 15% corn bran in diet, 30bran is 30% corn bran in diet.
[b]Total across day rumen pH variability.

Table 4. BCP estimates from duodenal purine concentration and urinary allantoin excretion.

Item[a]	15CS	30CS	45CS	SE	Linear	Quad
Allantoin mmol/d	136	151	185	11	.01	.10
BCP g/d	549	674	705	51	.01	.17
NRC[b] g/d	836	890	900			
NRC[c] g/d	723	843	952			

[a]15CS is 15% corn silage diet, 30CS is 30% corn silage diet, 45CS is 45% corn silage diet.
[b]NRC predicted production of BCP using actual DMI, and correcting eNDF to actual pH measured.
[c]NRC predicted production of BCP using actual DMI without correcting rumen pH, but using assumed eNDF values for corn silage.

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