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Effects of Corn Bran and Degradable Protein Source on Finishing Heifer Performance and Estimates of Microbial Protein Supply in High Moisture Corn Finishing Diets

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Summary

A feeding trial was conducted to evaluate performance and estimates of microbial CP (MCP) supply in high moisture corn finishing diets with corn bran addition and different sources of degradable protein. Corn bran increased intake throughout the feeding period but decreased performance after day 42. Microbial efficiency and MCP were unaffected by corn bran addition, but MCP increased with increasing urea level. Performance was increased for the first 42 days when SBM was fed relative to urea, but microbial efficiency and MCP were unaffected. Supplemental DIP level did not affect MCP estimates. Estimates of MCP from allantoin were low and variable but did reflect differences that could be explained with performance.

Introduction

Purine flow to the duodenum is commonly used to estimate microbial CP (MCP) supply in ruminants. Previous research (2001 Nebraska Beef Report, pp. 115-116) has shown a strong linear relationship between urinary excretion of allantoin and purine flow to the duodenum. Several studies in calves, sheep and lactating dairy cows have compared MCP estimates from purine derivative excretion in total urine collections to values estimated using allantoin to creatinine ratios in spot urine samples. The two methods have been shown to yield similar results but have not been studied in finishing cattle.

Corn bran contains highly digestible NDF and can reduce the incidence of subacute acidosis in finishing diets resulting in increased DMI and ADG and improved feed conversion (1997 Nebraska Beef Report, pp. 72-74). In vitro research has demonstrated that lower ruminal pH decreased microbial efficiency and MCP flow. Ruminant bacteria can use a non-protein nitrogen source like urea, but some microbes may have a requirement for true protein and amino acids. As a result, addition of a true protein source like soybean meal (SBM) would increase microbial efficiency and flow relative to urea. The objective of this trial was to evaluate estimates of MCP flow from allantoin to creatinine ratios in spot urine samples by formulating diets that were expected to result in different MCP flows. In addition, this was done in a typical production setting with a larger number of animals than can be used in a metabolism setting.

Procedure

One hundred-twenty crossbred yearling heifers averaging 768 $\pm$ 44 lb (initial BW) were used in a randomized complete block design. Heifers were split into four blocks by initial weight, stratified by weight within block and assigned randomly to one of 15 dietary treatments (8 heifers/treatment). Base diets were a high-moisture corn (HMC) diet and a diet with corn bran (BRAN) replacing 20% HMC (DM basis) (Table 1). Five levels of urea were added to the HMC and

Table 1. Composition of experimental diets (% of DM).

	Level of Supplemental DIP[b]				
Diet/Ingredient[a]	0	25	50	75	100
HMC					
High-moisture corn	88.3	88.3	88.3	88.3	88.3
Cottonseed hulls	6.7	6.7	6.7	6.7	6.7
Dry supplement[c]	5.0	5.0	5.0	5.0	5.0
Urea	0.00	0.45	0.90	1.35	1.80
BRAN					
High-moisture corn	68.3	68.3	68.3	68.3	68.3
Corn bran	20.0	20.0	20.0	20.0	20.0
Cottonseed hulls	6.7	6.7	6.7	6.7	6.7
Dry supplement[c]	5.0	5.0	5.0	5.0	5.0
Urea	0.00	0.45	0.90	1.35	1.80
SBM					
High-moisture corn	68.3	64.4	60.5	56.6	52.7
Corn bran	20.0	20.0	20.0	20.0	20.0
Soybean meal	0.0	3.9	7.8	11.7	15.6
Cottonseed hulls	6.7	6.7	6.7	6.7	6.7
Dry supplement[c]	5.0	5.0	5.0	5.0	5.0

[a]HMC=high-moisture corn diet, BRAN=corn bran diet, SBM=soybean meal diet.
[b]Level is the % of maximum supplemental DIP (i.e. 100=1.8% urea or 15.6% SBM).
[c]All diets supplemented to contain a minimum of 0.6% Ca, 0.24% P, 0.6% K, and 0.1% S. All diets contained 32 g/ton monensin and 11 g/ton tylosin and provided 0.05 mg/head/day MGA.

Table 2. Effect of corn bran inclusion and dietary urea level on finishing performance and carcass traits of finishing heifers.

Diet:	BRAN					HMC						*P*-value[b]		
Level:[a]	0	25	50	75	100	0	25	50	75	100	SEM	D	L	D x L
Day 0 – 42														
DMI, lb[c]	17.2	19.1	20.2	20.2	18.7	18.5	18.3	18.9	18.3	18.9	0.4	0.04	0.01	0.01
ADG, lb[d]	2.09	2.77	3.04	2.97	2.90	2.35	2.53	2.64	2.71	3.12	0.20	0.44	<0.01	0.27
feed/gain[d]	8.26	6.94	6.71	6.85	6.67	8.00	7.25	7.19	6.76	6.10	0.49	0.86	<0.01	0.62
Day 42 – end														
DMI, lb	17.8	18.9	20.5	20.9	18.9	18.9	17.4	18.5	18.0	18.9	0.9	0.06	0.35	0.13
ADG, lb	2.42	2.49	2.62	2.64	2.29	3.06	2.88	3.01	2.82	2.66	0.26	0.01	0.70	0.93
feed/gain	7.30	7.52	7.87	7.87	8.26	6.29	5.99	6.13	6.49	7.09	1.00	<0.01	0.46	0.95
Day 0 – end														
DMI, lb[c]	17.6	18.9	20.5	20.7	18.9	17.6	17.6	18.7	18.0	18.9	0.7	0.03	0.13	0.03
ADG, lb	2.27	2.62	2.77	2.75	2.49	2.77	2.75	2.88	2.79	2.88	0.20	0.04	0.51	0.64
feed/gain	7.75	7.19	7.41	7.52	7.57	6.85	6.41	6.49	6.58	6.53	0.45	<0.01	0.77	0.99
A:C ratio[e]	0.97	1.09	1.19	1.11	1.04	1.04	1.05	1.20	1.05	1.24	0.07	0.44	0.13	0.42
Urine volume, L/day	38.7	39.3	29.0	34.7	31.8	32.1	25.7	46.1	32.1	64.0	9.5	0.38	0.49	0.10
MCP, g/day[fg]	431	583	630	571	494	528	512	639	517	561	52	0.77	0.05	0.41
MCP/DMI, g/lb[f]	22.7	29.2	28.3	26.2	24.0	26.4	26.8	30.9	24.7	27.1	6.9	0.47	0.22	0.62
MCP/TDNI, g/lb[fh]	25.6	33.4	32.4	29.8	27.1	28.6	29.2	34.0	26.7	29.5	12.7	0.96	0.21	0.62

[a]Urea levels for each diet represent % of maximum amount of urea (i.e. 100=1.8% of diet DM).
[b]D=diet effect, L=effect of urea level, D x L=interaction of diet and level.
[c]Quadratic effect of urea level within BRAN (*P*<0.01).
[d]Linear effect of urea level (*P*<0.01).
[e]Allantoin to creatinine ratio.
[f]MCP=microbial crude protein.
[g]Quadratic effect of urea level (P<0.01).
[h]TDNI=TDN intake.

BRAN diets at 0, 0.45, 0.90, 1.35, and 1.80% of the diet DM. Additionally, the BRAN diet was fed with five levels of SBM at 0, 3.9, 7.8, 11.7, and 15.6% of the diet DM (Table 1) replacing HMC. Levels of SBM were calculated to be equal in degradable intake protein (DIP) to levels of urea.

Heifers were individually fed once daily using electronic Calan gates. Heifers were adapted to their respective finishing diet by gradually increasing the amount of feed offered until heifers reached ad libitum intake. Initially, intake was limited to 1.5% (DM basis) of average initial BW (11.4 lb DM). Feed offered was subsequently increased by 0.5 lb/day (DM basis) until ad libitum intake was reached (approximately 20 days).

Each weight block was implanted with Synovex-Plus approximately 100 days before slaughter with the heaviest block being fed 86 days, the two intermediate blocks being fed 114 days and the lightest block being fed 129 days. Final weight was calculated from hot carcass weight based on a common dress (62%) and used to calculate ADG and feed efficiency.

Spot urine samples were collected on days 19 to 21, days 61 to 63 and days 103 to 105. The molar ratio of allantoin to creatinine was calculated for each urine sample. We assumed daily urinary creatinine output was equal to 16.4 mg/lb BW. To calculate daily allantoin output (moles/day), the allantoin to creatinine ratio was multiplied by assumed daily creatinine output. A set of equations outlined previously (2002 Nebraska Beef Report, pp. 66-68) were used to calculate MCP production (g/day) based on daily urinary allantoin output. Microbial efficiency (g/lb) was calculated by dividing the estimate of MCP by the DMI for the day prior to urine collection. In a companion metabolism trial (2004 Nebraska Beef Report, pp. 28), the HMC and BRAN diets were fed with the mid-level (0.9%) of urea and the BRAN diet was fed with the mid-level (7.8%) of SBM. That trial found total-tract DM digestibilities of 85.1, 81.8, and 80.2% for the HMC, BRAN, and SBM diets, respectively. These values were used to calculate microbial efficiency based on TDN intake.

Performance data were analyzed using the Mixed procedure of SAS. Two separate 2 x 5 factorial treatment structures were analyzed. The first analysis compared corn bran inclusion and five levels of urea. The second analysis compared effects of source of supplemental DIP (urea or SBM) at five levels. Urine data were averaged across each 3 day collection period for individual animals. These average values were termed time 1 (T1), time 2 (T2), and time 3 (T3). Data were analyzed as repeated measures using the Mixed procedure of SAS in both of the treatment structures previously discussed. Time period represented repeated observations.

Results

Previous research (1997 Nebraska Beef Report, pp. 72-74) found that replacing dry-rolled corn (DRC) with 15% corn bran resulted in increased DMI and ADG with improved feed conversion. In the current trial, 20% corn bran addition to a HMC-based diet resulted in a 6% increase (*P*=0.03) in DMI, 8% decrease (*P*=0.04) in ADG, and 14% decrease (*P*<0.01) in

(Continued on next page)

Table 3. Effect of supplemental degradable protein source and level in diets containing corn bran on finishing performance and carcass traits of finishing heifers.

Diet:	Urea					SBM						*P*-value[b]		
Level:[a]	0	25	50	75	100	0	25	50	75	100	SEM	D	L	D x L
Day 0 – 42														
DMI, lb[c]	17.2	19.1	20.2	20.2	19.4	19.1	19.6	20.0	20.2	18.7	0.4	0.34	<0.01	0.10
ADG, lb[c]	2.09	2.77	3.04	2.97	2.90	2.71	2.75	3.70	3.48	3.30	0.22	<0.01	<0.01	0.47
feed/gain[d]	8.26	6.94	6.71	6.85	6.67	7.19	7.14	5.40	5.78	5.68	0.48	<0.01	<0.01	0.24
Day 42 – end														
DMI, lb	17.8	18.9	20.5	20.9	18.9	20.9	19.6	20.9	19.8	18.3	0.9	0.30	0.11	0.18
ADG, lb	2.42	2.49	2.62	2.64	2.29	2.60	2.71	2.86	2.53	2.62	0.20	0.15	0.64	0.81
feed/gain	7.30	7.52	7.87	7.87	8.26	7.94	7.19	7.30	7.94	6.99	0.60	0.34	0.87	0.46
Day 0 – end														
DMI, lb[c]	17.6	18.9	20.5	20.7	18.9	20.2	19.6	20.5	20.0	18.9	0.7	0.21	0.05	0.16
ADG, lb[c]	2.27	2.62	2.77	2.75	2.49	2.64	2.71	3.19	2.84	2.90	0.15	<0.01	0.01	0.64
feed/gain[e]	7.75	7.19	7.41	7.52	7.57	7.63	7.25	6.41	7.04	6.41	0.33	<0.01	0.06	0.10
A:C ratio[f]	0.98	1.10	1.20	1.12	1.05	1.08	1.05	1.03	0.92	1.03	0.08	0.20	0.75	0.33
Urine volume, L/day	39.1	39.7	29.4	35.0	32.2	22.3	36.8	28.2	26.8	30.7	10.0	0.30	0.88	0.91
MCP, g/day[g]	437	590	635	577	500	519	548	518	465	498	58	0.26	0.26	0.31
MCP/DMI, g/lb[g]	24.3	30.7	29.8	27.8	25.7	24.4	28.0	25.0	22.4	25.0	3.0	0.13	0.35	0.81
MCP/TDNI, g/lb[gh]	29.8	37.7	36.5	34.1	31.4	30.5	34.9	31.2	28.0	31.3	3.7	0.21	0.35	0.82

[a]Supplemental DIP levels represent % of maximum amount of urea or SBM in diet (i.e. 100=1.8% urea or 15.6% SBM).
[b]S=source effect, L=effect of supplemental DIP level, S x L=interaction of source and level.
[c]Quadratic effect of supplemental DIP level ($P<0.01$).
[d]Quadratic effect of supplemental DIP level ($P=0.04$).
[e]Linear effect of supplemental DIP level ($P=0.03$).
[f]Allantoin to creatinine ratio.
[g]MCP=microbial crude protein.
[h]TDNI=TDN intake.

feed conversion across the entire feeding period (Table 2). These effects occurred from day 42 to the end of feeding period, because corn bran addition resulted in a 3% increase ($P=0.04$) in DMI with no difference in ADG or feed conversion during the first 42 d (Table 2). Corn bran could be more effective when fed in HMC instead of DRC-based finishing diets because more starch would be degraded in the rumen at a faster rate for HMC. Perhaps our failure to observe a benefit of corn bran was due to relatively low feed intake. Our results did show that corn bran was more effective early in the feeding period when cattle were being adapted to a HMC-based finishing diet, and subacute acidosis may have been more prominent.

The hypothesis for this trial was that corn bran would reduce the incidence of acidosis and increase microbial efficiency and MCP flow. Based on results discussed previously, acidosis may not have been an issue. As a result, corn bran addition did not change microbial efficiency or MCP estimates (Table 2.). Microbial efficiencies were calculated by dividing MCP estimates by TDN intake which is a measure of total-tract digestibility. We were unable to calculate microbial efficiency based on rumen available energy intake, but these efficiencies would have been higher than those reported because they would only account for ruminal digestion instead of total-tract digestion. Additionally, microbial efficiency based on ruminal available energy would probably have been higher for the BRAN diet because ruminal digestion of corn bran would be lower than HMC. Preliminary results of a current research trial have shown ruminal digestibility of corn bran to be half of HMC. This difference in ruminal digestibility would result in a 10% increase in our reported microbial efficiencies for the BRAN diet (i.e. 20% inclusion x 50% lower digestibility). Much of the energy value assigned to corn bran is attributed to its value in reducing the incidence of acidosis. Therefore, corn bran may have only increased microbial efficiency by enough to offset the decrease in energy intake. Increased performance for the HMC diet was a result of total dietary energy content.

Results in this Nebraska Beef Report (pp. 28) from a companion metabolism trial conflict with results of the current study showing corn bran addition increased ruminal pH resulting in increased estimates of microbial efficiency and flow. The companion study was conducted with six heifers having an average weight of 1311 lb while the current study evaluated heifers across the feeding period. Corn bran increased DMI by approximately 13% in the metabolism trial compared to 6% in the current trial.

Previous research (2001 Nebraska Beef Report, pp. 54-57) determined that 10.1% (DM basis) dietary DIP resulted in the lowest feed conversion for steers fed HMC-based finishing diets. In contrast, the current trial showed no effect of increasing DIP level on performance across the entire feeding period implying DIP requirements were met with no added urea. How-

ever, ADG increased by 36% and feed conversion decreased by 21% from the lowest to highest level of urea during the first 42 days of the feeding period (Table 2). Our highest level of urea resulted in dietary DIP values of 10.6 and 11.6% for HMC and BRAN diets, respectively. Therefore, our results were in agreement with previous work only for the first 42 days heifers were on feed.

Estimates of MCP flow to the duodenum increased quadratically ($P<0.01$) across levels of urea reaching a maximum at 0.9% (DM basis) which represented 8.1 and 9.1% dietary DIP (DM basis) for HMC and BRAN diets, respectively (Table 2). These values for dietary DIP are lower than those determined based on performance for the first 42 days of the feeding period but higher than those based on performance from day 42 to the end; however, they represent the midpoint of these two extremes.

Across the entire feeding period in the current trial, ADG increased ($P<0.01$) and feed conversion decreased ($P<0.01$) by 11 and 7%, respectively, when SBM was the source of supplemental DIP (Table 3). We found an increase of 16% in ADG ($P<0.01$) and a decrease of 12% in feed conversion ($P<0.01$) for SBM relative to urea from day 0 to 42 with no differences from day 42 to the end of the feeding period (Table 3). The reason for a response only during the first 42 days may have been due to the undegradable intake protein (UIP) in SBM and its contribution to metabolizable protein (MP). The MP balance (data not shown) for both sources of supplemental DIP was negative at the two lowest levels. The balance was only marginally positive across the three highest levels of urea. Compared to urea, SBM improved ADG and feed conversion at the three highest levels of supplemental protein.

We hypothesized replacing urea with SBM would increase microbial efficiency and MCP flow. We saw no effect of source of supplemental DIP on microbial efficiency or MCP estimates (Table 3). These results are in agreement with research reported in this publication (pp. 28) from a companion metabolism trial, but are in conflict with other reported research results. The conflicting studies were conducted with DRC-based diets. It seems plausible that the higher DIP value for HMC relative to DRC would provide microbes with more true protein decreasing the response to SBM as a supplemental DIP source. Additionally, in the present trial, SBM and urea were compared in corn bran containing diets where risk of acidosis had been reduced. These results are in agreement with the possibility that performance differences were a response to UIP in SBM and not to true protein increasing microbial efficiency.

From day 0 to 42 of the feeding period, ADG ($P<0.01$) and feed efficiency ($P=0.04$) showed a quadratic response to increasing supplemental DIP level (Table 3). The lowest value for feed conversion was at the mid-level which represented 9.1 and 8.8% dietary DIP (DM basis) for the urea and SBM sources, respectively. The problem with using performance to determine when the DIP requirement was met is that performance responses were potentially confounded with UIP supplied by SBM. There was no effect of supplemental DIP level on estimates of MCP flow (Table 3). It is not clear why estimates of MCP did not respond to increasing levels of supplemental DIP. Estimates of MCP across levels of SBM were variable and seem to be the limiting factor in finding an overall effect of level. It is important to remember that SBM replaced HMC in the diet while urea replaced supplement carrier. Increasing levels of SBM may have decreased ruminal available energy limiting the need for DIP. This still argues that increased performance for SBM was a response to UIP, but it does not explain why estimates of MCP were not lower for SBM versus urea. However, if microbial efficiency were calculated based on ruminal available energy, it may have been higher for SBM.

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