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Diurnal and Dietary Impacts on Purine Derivative Excretion from Spot Samples of Urine

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Summary

An individual feeding experiment was conducted to estimate diurnal and dietary impacts on microbial CP (MCP) production estimated from urinary purine derivative (PD) and creatinine excretion. Heifers were fed one of three diets formulated to produce differences in MCP production: an 85% steam-flaked corn-based diet (SFC); the SFC diet with 1.5% urea (UREA); or a corn milling byproduct-based diet (BYPROD). Spot samples of urine were collected at 0700 and 1700 hours. No urine collection time x dietary treatment interactions were present for any variable. Dry matter intake, ADG, and F:G were poorest with the SFC treatment. Urinary PD:creatinine (PD:C) ratio was greatest with the BYPROD treatment and lowest with the SFC treatment, measuring 0.94, 1.18, and 1.25 for the SFC, UREA, and BYPROD treatments, respectively. Regardless of diet, PD:C was greater with samples collected later in the day, and differences in PD:C due to diet can be observed regardless of collection time.

Introduction

Quantification of microbial crude protein (MCP) production is important in determining the adequacy of diets fed to feedlot cattle. The most common method of determining MCP production has been through duodenal purine measurement. Purines are a microbial flow marker measured in the small intestine. However, this method requires duodenally fisulated animals, which limits the number of animals in an experiment and relegates these animals to a metabolism setting, which can affect results.

Urinary purine derivatives (PD) allantoin and uric acid are degradation products of purines and have been validated as markers for MCP. In addition, urinary creatinine can be used as a marker of urine output, and is excreted at a constant of 28 mg/kg BW (*2004 Nebraska Beef Report,* pp. 100-102*)*. Therefore, by measuring urinary PD and creatinine, spot samples of urine may be used to estimate MCP. This allows use of greater number of animals, and allows for experiments in a typical production setting.

Estimates of MCP from urinary PD excretion may vary depending on time of urine collection. Therefore, the objectives of this experiment were to evaluate urinary PD:C as a tool to estimate MCP production in a production setting, and determine if time of urine collection impacts MCP estimation using urinary PD and creatinine measurements from spot samples of urine.

Procedure

One hundred-sixteen crossbred heifers (897 ± 71 lb) were arranged into a randomized complete block design with a 3 x 2 factorial arrangement of treatments. Heifers were stratified by weight into one of four individual-feeding barns and fed one of 3 diets formulated to produce differences in MCP production as measured by urinary PD and creatinine excretion: 1) a steam-flaked corn-based diet containing 9.6% CP (SFC); 2) the SFC diet with 1.5% supplemental urea resulting in 13.7% CP (UREA); or 3) a corn milling byproduct-based diet with 25% SFC, 30% corn bran, and 30% wet corn gluten feed, resulting in 14.1% CP (BYPROD). Sorghum silage was included in all diets at 10% of DM. Each diet supplied 320 mg Rumensin/heifer daily and 90 mg Tylan/heifer daily. Heifers were fed once daily and implanted with Revalor-H at the beginning of the experiment. Animals were individually fed using Calan gates, and orts were subtracted from the daily feed offering to determine daily DMI for each heifer. The experiment was 84 days in length.

Spot samples of urine were collected from 58 heifers at 0700 hours and from the remaining 58 heifers at 1700 hours for three consecutive days at the end of three 28-day periods. All heifers within a barn were sampled at the same collection time. Individual animal BW were determined at each urine collection. Heifers were slaughtered at the conclusion of the experiment (Tyson Foods, Inc., West Point, Neb.) and carcass data were collected. Urine collected during the experiment was composited within 28-day period. Purine derivatives and creatinine were analyzed using high pressure liquid chromatography. Urinary creatinine was analyzed to estimate urinary output assuming creatinine output of 28 mg/kg BW.

Data were analyzed as a 3 x 2 factorial within a randomized complete block design using the Mixed procedure of SAS. Individual feeding barn served as the block, and was considered a random effect. Dietary treatment and time of day of urine collection were considered fixed effects, and the interaction between the two was initially tested for all variables. Least squares means were separated using the PDIFF statement in SAS when protected by a significant ($P<0.05$) *F*-test.

Results

No dietary treatment x urinary collection time interactions occurred for any variable, therefore live animal performance data and carcass characteristics are presented in Table 1 as the main effect of dietary treatment. Dietary treatments were

(Continued on next page)

formulated to create treatment differences in MCP production which led to expected differences in live and carcass performance. Heifers consuming the BYPROD treatment had a greater ($P<0.05$) DMI than heifers consuming either the SFC or UREA treatments, and DMI with the UREA treatment was also greater ($P<0.05$) than that of the SFC treatment, averaging 17.4, 19.5, and 22.9 lb/day for the SFC, UREA, and BYPROD treatments, respectively. Differences in DMI can be attributed to a deficiency in DIP with the SFC treatment, while it appears that the BYPROD treatment also may have provided ruminal acidosis control due to the replacement of highly-fermentable starch from SFC with slower-fermenting corn milling by-products. Average daily gain was lower (2.44 lb/day; $P < 0.05$) with the SFC treatment than with either the UREA (3.52 lb/day) or BYPROD (3.69 lb/day) treatments. The UREA and BYPROD treatments did not differ ($P>0.10$) for ADG. Feed conversion (F:G) was poorest ($P<0.05$) with the SFC treatment, intermediate with the BYPROD treatment, and lowest with the UREA treatment, measuring 7.13, 5.54, and 6.21 for the SFC, UREA, and BYPROD treatments, respectively.

Carcass characteristics generally followed the live performance results, with heifers consuming the SFC treatment having lower ($P<0.05$) HCW and 12th rib fat thickness than either the UREA or BYPROD treatments. The BYPROD treatment also produced a greater ($P<0.05$) marbling score than the SFC treatment. No treatment differences ($P>0.10$) were observed for dressing percentage or LM area.

A number of variables currently limit the ability to predict absolute MCP flow values from PD:C values; however, the PD:C ratio can be used to estimate relative differences in MCP flow. Therefore PD:C ratios, rather than MCP estimates, will be presented in this discussion. Heifers consuming the BYPROD treatment produced the greatest ($P<0.05$) urinary PD:C ratios, with the UREA treatment being intermediate, and the SFC treatment being the lowest,

Table 1. Main effects of dietary treatment on live performance and carcass characteristics.

	Treatment[a]			
Item	SFC	UREA	BYPROD	*P*-value
DMI, lb/day	17.4[e]	19.5[d]	22.9[c]	<0.01
ADG, lb	2.44[d]	3.52[c]	3.69[c]	<0.01
F:G	7.13[e]	5.54[c]	6.21[d]	<0.01
Carcass weight, lb	720[d]	772[c]	766[c]	<0.01
Dressing %	62.4	63.1	62.3	0.15
Marbling[b]	501[d]	512[cd]	539[c]	0.03
Longissimus area, in^2	14.0	14.0	14.4	0.54
12th rib fat depth, in	0.38[d]	0.45[c]	0.48[c]	<0.01

[a]SFC = 85% SFC, 9.6% CP; UREA = 85% SFC + 1.5% urea, 13.7% CP; BYPROD = 25% SFC, 30% corn bran, 30% wet corn gluten feed, 14.1% CP.
[b]Marbling score called by USDA grader where 500 = small[0] and 550 = small[50].
[cde]Values within the same row with uncommon superscripts differ ($P<0.05$).

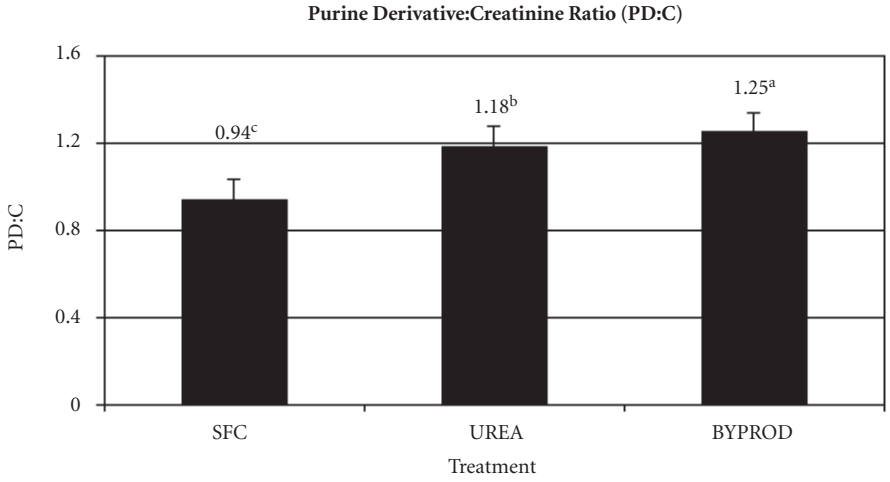

Figure 1. Main effect of dietary treatment on urinary PD:C ratio. Diet $P < 0.01$; Diet x Urine collection time $P=0.98$.
[abc] Unlike superscripts differ ($P<0.05$).

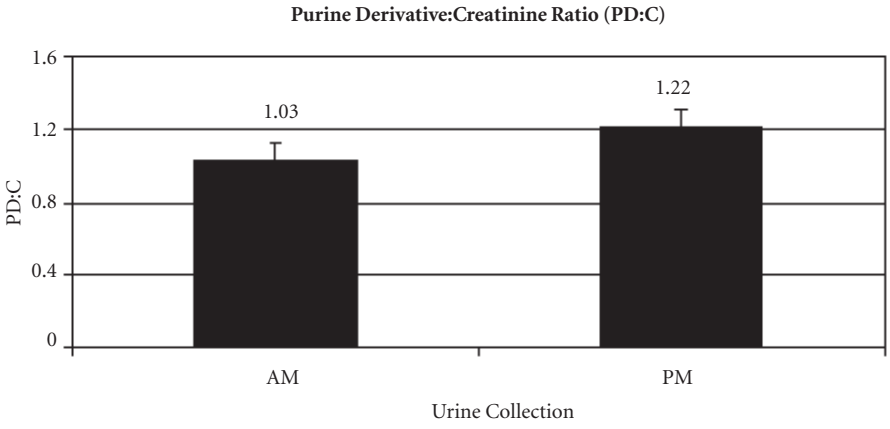

Figure 2. Main effect of urine collection time on urinary PD:C ratio. Urine collection time $P < 0.01$; Diet x Urine collection time $P = 0.98$.

measuring 0.94, 1.18, and 1.25 for the SFC, UREA, and BYPROD treatment, respectively (Figure 1). This indicates that MCP flow was greatest with the BYPROD treatment and lowest with the SFC treatment, suggesting that the BYPROD treatment may have provided a more favorable ruminal environment for MCP synthesis than when diets contained a large proportion of SFC. The SFC treatment had a low CP and DIP content, resulting in the lowest PD:C values among the dietary treatments. Using ruminal digestibility values from a companion metabolism study (*2007 Nebraska Beef Report* pp. 100-102*)*, digestible OM intake with the SFC treatment was 73.9% of digestible OM intake of the BYPROD treatment, and PD:C with the SFC treatment was 75.2% of that of the BYPROD treatment, suggesting that ruminally digestible OM intake explains most of the difference in PD:C. These results were expected based on the composition of the dietary treatments, and suggests that urinary PD:C measurements can be utilized as a tool to estimate treatment differences in ruminal MCP production. When urine samples were collected in the PM, measurement of PD:C to estimate MCP flow was greater than when samples were collected in the AM (Figure 2). It is not yet clear why this diurnal effect is present. It is important to note, however, that these heifers were fed once daily at 0800 h, and this may have an impact on MCP flow, digestion, and subsequent PD:C in urine.

Conclusions

Dietary treatments produced expected differences in PD:C, suggesting that urine measurements can be used to predict treatment differences in MCP production. Urine samples collected in the PM had a greater PD:C than those collected in the morning. The mechanisms to explain this are yet unknown, and require further exploration. There were no dietary treatment x urine collection time interactions, suggesting 1) regardless of diet, PD:C was greater in the afternoon; and 2) differences in PD:C can be observed regardless of collection time.

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