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Relationship of Metabolizable Protein Balance, Purine Derivative Excretion, and 3-Methyl Histidine Excretion to Feed Efficiency in Individually Fed Finishing Heifers

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Summary

Individually fed heifers were used to determine the relationship of 3-methyl histidine, purine derivatives, and metabolizable protein balance to feed efficiency. Heifers were fed finishing diets that were either deficient or sufficient in metabolizable protein. Urine samples were collected and analyzed for early, late, and entire feeding period concentrations of 3-methyl histidine, purine derivatives, and creatinine. Results from this study indicated a negative relationship between feed efficiency and metabolizable protein balance, and no relationship between 3-methyl histidine excretion and feed efficiency, suggesting that protein turnover and microbial protein synthesis are not related to feed efficiency

Introduction

In cattle production we are always looking for ways to explain differences among cattle in feed efficiency (G:F) and methods to improve G:F. Protein supply can have an impact on BW gain and feed efficiency. Metabolites excreted in urine can be used to measure protein turnover (3-methyl histidine; 3MH) and microbial protein production (purine derivatives; PD). As is the case with energy, protein use efficiency may be different among animals, especially when fed different finishing diets. This suggests that cattle may differ in protein turnover rates leading to differences in measured feed efficiency. Greater protein turnover increases 3MH excretion in the urine or a greater 3MH-to-creatinine (Cr) ratio. Urinary Cr can be used as a marker of urine output. Therefore, by measuring urinary PD, 3MH, and Cr in spot samples of urine, microbial CP production and protein turnover can be estimated. Using spot samples of urine allows for use of a greater number of animals than metabolism studies and allows for experiments in typical production settings. In addition, the metabolizable protein balances (MPB) may help explain differences observed in G:F. Therefore, the objective of this study was to evaluate the relationship of PD, 3MH, and MPB to G:F.

Procedure

Data from an experiment (*2007 Nebraska Beef Report,* pp. 103-105) utilizing 78 individually fed heifers (912 ± 72 lb) were used to determine relationships of G:F to MPB, excretion of PD:Cr, and 3-MH:Cr excretion. Heifers were fed steam-flaked corn-based diets containing either 0 (NEG) or 1.5% (POS) urea for 95 days, resulting in CP levels of 9.6% and 13.7% for NEG and POS, respectively. Animal BW and spot urine samples were collected at 3 different times (28, 56, and 84 days) and urine was analyzed for PD, Cr, and 3MH using HPLC. Data from this experiment were analyzed by period because predicted metabolizable protein and energy requirements changed for the heifers as BW increased. Data were analyzed from 3 periods: early (day 1 to 55; urine 28 day), late (day 56 to 95; urine 84 day), and overall (day 1 to 95; urine days 28, 56, and 84).

Daily gain, DMI, and final BW adjusted to equal (28%) empty body fat were used as inputs for the 1996 NRC model to determine MPB. Data were analyzed using the PROC CORR procedure of SAS to determine the correlations (r) of PD:Cr to G:F; MPB to G:F; 3MH to G:F; DMI to PD:Cr; DMI to MPB; and DMI:3MH. Because heifers were individually fed, animal was the experimental unit. Results are presented by treatment and significance was determined when $P < 0.05$.

Results

Animal performance for this experiment is presented in the *2007 Nebraska Beef Report*, pp. 103-105 (Table 1). In the early period, a positive relationship was observed between PD:Cr and G:F in both the POS ($P = 0.02$) and NEG ($P < 0.01$) diets. In addition, a negative relationship between MPB and G:F was observed in both diets during the early period ($P < 0.01$). For the overall feeding period, heifers fed NEG exhibited a negative relationship between MPB and G:F ($P < 0.01$) and a positive relationship between DMI and MPB ($P < 0.01$). When heifers were fed POS, a negative relationship between MPB and G:F ($P < 0.01$) and a positive relationship between MPB and DMI ($P < 0.01$) were observed. In addition both the NEG and POS treatments exhibited positive relationships for DMI and PD:Cr. Relationships between 3MH and other measured variables were not significant for either the POS or NEG treatments.

The negative relationship between MPB and G:F is counterintuitive. This seems to indicate that the more efficient animals were more efficient in either production or utilization of metabolizable protein. Three-methyl histidine is a measure of muscle protein turnover. A lower level of 3MH (lower 3MH:Cr ratio) would indicate lower protein turnover and therefore lower metabolizable protein requirements. We found no relationship between 3MH and G:F,

suggesting muscle turnover is not the explanation for the MPB to G:F relationship.

Another possible explanation for the G:F-to-MPB relationship is protein supply. If heifers eat more, more microbial protein is expected. That was demonstrated with the relationship between DMI and PD:Cr ratio. For the overall feeding period, there was not a relationship between PD:Cr and G:F, suggesting microbial protein synthesis was not the explanation for the MPB to G:F relationship. However, because the protein requirement prediction was higher for heifers during the first part of the feeding period, we determined the relationship of PD:Cr to G:F for the early period. The relationship was positive and significant ($P = 0.02$) for both POS and NEG treatments. This is an indication that microbial protein synthesis differences among the heifers may partially explain the MPB to G:F relationship.

Results from this study indicate no relationship between 3MH excretion and G:F, suggesting that protein turnover did not explain differences in feed efficiency. In addition it was a consistent response in both diets that MPB and G:F were negatively related. The lack of response between 3MH excretion and G:F and the positive response of PD to G:F in the first period lead us to conclude differences in feed efficiency are perhaps more closely related to microbial protein and efficiency of microbial crude protein production than to protein turnover within the animal.

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

	Treatment[2]		
Item	SFC	UREA	*P*-value
DMI, lb/day	17.4	19.5	< 0.01
ADG, lb	2.44	3.52	< 0.01
F:G	7.13	5.54	< 0.01
Carcass weight, lb	720	772	< 0.01
Dressing %	62.4	63.1	0.15
Marbling[3]	501	512	0.03
Longissimus area, in^2	14.0	14.0	0.54
12th rib fat depth, in	0.38	0.45	< 0.01

[1]Data presented are from *2007 Nebraska Beef Report*, pp. 103-105.
[2]SFC = 85% SFC, 9.6% CP; UREA = 85% SFC + 1.5% urea, 13.7% CP.
[3]Marbling score called by USDA grader where 500 = small^{00} and 550 = small^{50}.

Table 2. Relationship of excreted metabolites and feeding performance measures[1].

			P-value[4]	
Item	POS[2]	NEG[3]	POS	NEG
Early Period[5]				
PD:Cr and G:F	0.38	0.54	0.02	< 0.01
MPB and G:F	- 0.77	- 0.81	< 0.01	< 0.01
3MH and G:F	- 0.27	- 0.16	0.10	0.32
DMI and PD:Cr	0.27	0.35	0.10	0.03
DMI and MPB	0.47	0.08	< 0.01	0.61
DMI and 3MH	0.10	0.01	0.53	0.94
Overall[6]				
PD:Cr and G:F	- 0.05	- 0.11	0.78	0.54
MPB and G:F	- 0.79	- 0.65	< 0.01	< 0.01
3MH and G:F	- 0.08	0.14	0.63	0.37
DMI and PD:Cr	0.31	0.32	0.05	0.06
DMI and MPB	0.51	0.56	< 0.01	< 0.01
DMI and 3MH	0.00	0.05	1.00	0.77

[1]PD = purine derivative; Cr = creatinine; MPB = metabolizable protein balance; 3MH = 3-methyl histidine; RFI = residual feed intake.
[2] POS = 85% SFC + 1.5% urea, 13.7% CP.
[3]NEG = 85% SFC, 9.6% CP.
[4]*P*-value is represented for each variable within treatment.
[5]Early period = days 1 through 55 on feed.
[6]Overall period = days 1 through 95 on feed.