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Relationship Between Metabolizable Protein Balance and Feed Efficiency of Steers and Heifers

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Summary

Two individual feeding experiments were analyzed for the relationship between metabolizable protein (MP) balance and feed efficiency (G:F) in individually-fed steers and heifers. In Experiment 1, 29 crossbred steers were fed steam-flaked corn (SFC)-based diets containing either 0% or 1.2% urea (DM basis). In Experiment 2, 75 crossbred heifers were fed SFC-based diets with either 0% or 1.5% urea. The NRC (1996) MP model was used to determine individual degradable intake protein and MP balances. In both experiments there was a negative relationship within treatment between MP balance and G:F. These results were not expected, and three potential causes were proposed: conversion of MP to net protein; ruminal pH; and/or residual feed intake.

Introduction

Metabolizable protein (MP) is the sum of digestible microbial protein and digestible undegradable intake protein (UIP). Beef cattle feedlot diets often contain excess MP, but may be deficient in degradable intake protein (DIP). In these situations, urea is often added to diets to provide adequate DIP. It is unknown, however, what the relationship is between MP balance and feed efficiency (G:F). Therefore, the objective of this data analysis was to determine the relationship between MP balance and G:F in individually-fed steers and heifers.

Procedure

Data from two individual feeding experiments were analyzed to determine the relationship between MP balance and G:F. In Experiment 1, 29 crossbred steers (743 lb initial BW) were fed diets containing 84% steam-flaked corn (SFC), 11% sorghum silage, 5% molasses, and 5% dry supplement with either 0 (NEG) or 1.2% (POS) urea included in the dry supplement for 83 days. Corn gluten meal was also included in the POS treatment at 3.0% of DM. These diets resulted in dietary CP concentrations of 8.9% and 14.4% for NEG and POS, respectively. In Experiment 2, 75 crossbred heifers (897 lb initial BW) were fed diets containing 85% SFC, 10% sorghum silage, and 5% dry supplement with either 0 (NEG) or 1.5% (POS) urea included in the dry supplement for 84 days. This resulted in dietary CP concentrations of 9.6% and 13.7% for NEG and POS, respectively. In both experiments, cattle receiving the NEG treatment were in a negative MP balance and cattle receiving the POS treatment were in a positive MP balance based on feed efficiency and calculated (NRC, 1996) MP balance. Cattle were individually fed once daily using Calan gates, and orts were subtracted from the daily feed offering to determine daily DMI for each animal.

Each animal's individual ADG and DMI for the experiment were used for performance variable inputs in the 1996 NRC model to estimate MP balance of each individual animal within treatment. Individual animal final BW was adjusted to expected BW at 28% empty body fat using the procedures of Guiroy et al. (2001 *Journal of Animal Science*, Vol. 80, pp. 1791-1800) to calculate adjusted final BW. Feed ingredient nutrient compositions were also adjusted in the model to account for actual feed CP and DM during the experiment. The resulting MP balance from the model for each individual animal was compared to G:F for that animal.

Results

Performance data for each experiment are presented in Table 1. In Experiment 1 no statistical differences ($P > 0.10$) were observed for DMI, ADG, and G:F. Steers consuming POS did have numerically greater ($P = 0.16$) G:F compared to steers consuming NEG. In Experiment 2, DMI, ADG, and G:F were all greater ($P > 0.01$) with POS compared with NEG.

Cattle fed POS (balanced) diets had better G:F than those deficient in MP, however, the relationship of MP balance and G:F within treatments where the cattle were fed the same diet, was examined.

There was a significant relationship between MP balance and G:F for each treatment within experiment. In Experiment 1, the relationships observed had an $r^2 = 0.95$ and 0.60 for NEG and POS, respectively (Figure 1), while in Experiment 2, the relationships were $r^2 = 0.45$ and 0.40 for NEG and POS, respectively (Figure 2). In all cases, an increase in MP balance was associated with a decrease in G:F. This indicates that a lower MP balance resulted in an improvement in feed efficiency, suggesting that cattle in these experiments either had a greater MP supply than calculated by the model, or MP was used more efficiently by MP-deficient cattle.

(Continued on next page)

Table 1. Feedlot performance of cattle used for this analysis[a].

Item	Treatment NEG	POS	SEM	*P*-Value
Experiment 1				
DMI, lb/day	20.3	20.1	0.6	0.75
ADG, lb	3.29	3.55	0.40	0.27
G:F	0.162	0.177	0.008	0.16
Experiment 2				
DMI, lb/day	17.4	19.5	0.3	< 0.01
ADG, lb	2.44	3.52	0.11	< 0.01
G:F	0.141	0.181	0.008	< 0.01

[a]NEG = Cattle consuming SFC-based diets with no supplemental urea; POS = Cattle consuming SFC-based diets with either 1.2% (Exp 1) or 1.5% (Exp 2) supplemental urea.

We expected that an increase in MP would result in an increase in feed efficiency. Therefore, these results seem counterintuitive, and may be largely due to individual animal variation. Possible causes may be variation in conversion of MP to net protein (NP), variation in ruminal pH, and variation in residual feed intake.

It is assumed that MP is converted to NP with decreasing efficiency as animal BW increases. However, studies to confirm these assumptions have only used animals with a BW range of approximately 330-660 lb, with an assumed conversion of MP to NP of 0.492 thereafter. It is unknown how efficient heavier animals are in converting MP to NP, and the variation among animals at these heavier weights is also unknown.

A second potential source of animal variation is ruminal pH. Low ruminal pH may affect fiber and protein degradation and efficiency of microbial synthesis. Low ruminal pH may also decrease the efficiency with which microbes convert feed energy and nitrogen into protein. Individual animals can vary dramatically in their ability to adjust to a high-concentrate diet. Therefore, it would be expected that ruminal pH would vary considerably within and between treatments fed to cattle in a typical feedlot setting. Although ruminal pH was not measured in either of the experiments used for this analysis, previous work (*2007 Nebraska Beef Report*; pp. 100-102) suggests significant animal variation exists in ruminal pH patterns. In this previous experiment with rumen pH measured continuously with submersible pH probes in the rumen, pH can vary for animals fed the same diet. For example, Crawford et al. observed individual average pH varied from 5.16 to 5.89 for steers fed the same steam-flaked corn diet. For steers fed a byproduct based diet in the same experiment, ruminal pH varied from 5.68 to 6.12. These data demonstrate animal variation certainly exists for rumen pH which would likely affect MP balance and utilization by individual cattle.

There is considerable animal variation in feed intake above and below that expected or predicted based on size and growth rate. This difference in intake is termed residual feed intake (RFI). Variation in RFI is indicative of differences in efficiency of energy use. If RFI can vary due to differences in efficiency of energy utilization, it is logical to assume that variation in efficiency of protein utilization is also present, and could further explain the G:F responses to MP supply in these experiments.

In summary G:F in cattle was negatively related to MP balance. This result seems counterintuitive, as one would expect an improvement in animal efficiency as MP availability increased. Individual animal variation could be the primary cause of this relationship. Specifically, individual animal variation in conversion of MP to NP, ruminal pH, and RFI may help explain these results.

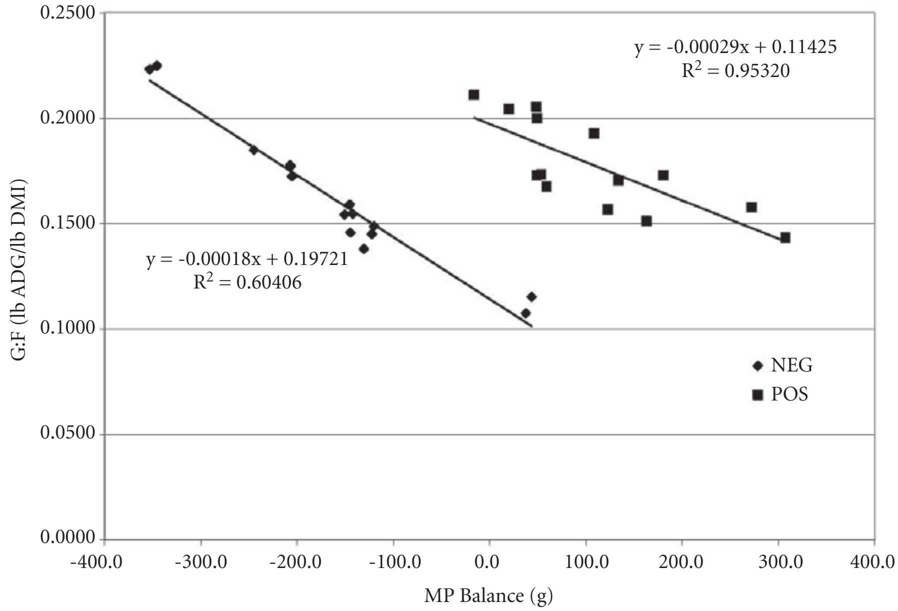

Figure 1. Regression of individual animal gain:feed on individual animal MP balance when steers were fed SFC-based diets with 0 or 1.2% urea (Data from Experiment 1).

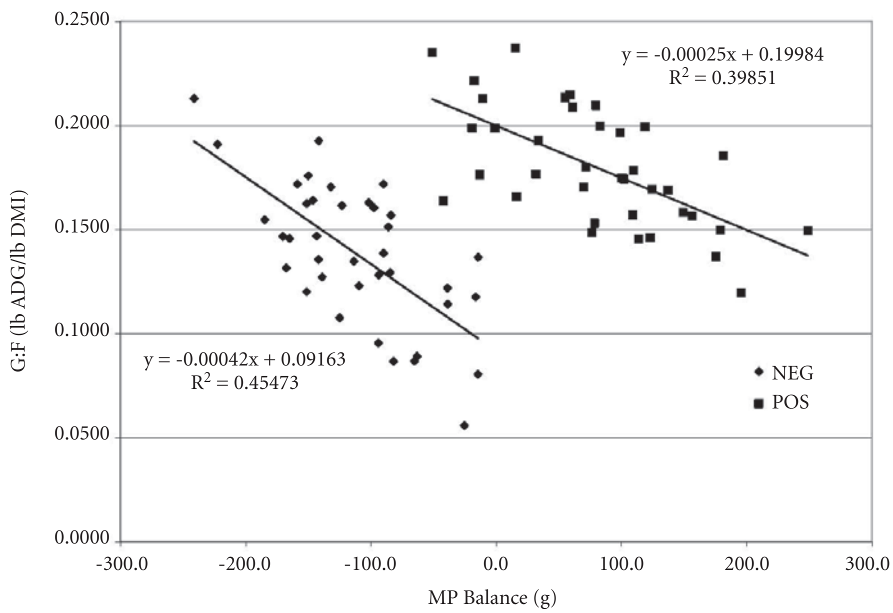

Figure 2. Regression of individual animal gain:feed on individual animal MP balance when heifers were fed SFC-based diets with 0 or 1.5% urea (Data from Experiment 2).

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