Research Summaries II

Dairy

Milk Urea Nitrogen as a Metabolic Indicator of Protein Feeding Efficiency on Dairy Farms

Linda D. Baker, *VMD, MS, Diplomate ACVN*
James D. Ferguson, *VMD, MS, Diplomate ACVN, ACT*
University of Pennsylvania
Kennett Square, PA

Introduction

Blood urea nitrogen (BUN) is elevated in cows fed excessive levels of protein. Overfeeding protein is a major economic cost to dairy producers and elevations in BUN result in adverse health and reproductive effects. A routine monitoring system for protein feeding is needed. Milk urea nitrogen (MUN) is highly correlated with BUN. Milk is collected monthly on many farms by DHIA testing centers and milk would be easier to obtain than blood for continuous monitoring of urea concentrations. The objective of the first study was to characterize the transfer of urea from plasma into milk following rapid IV infusion of urea into lactating dairy cows. The objective of the second study was to determine if milk urea concentration is sensitive to changes in dietary protein intake and if it would be feasible to use MUN to evaluate protein feeding on dairy farms.

Experiment 1: Urea Kinetics in Lactating Dairy Cows

Materials and Methods.

Four lactating dairy cows varying in stage of lactation and milk yield were used in a two day experiment. Prior to the start of the experiment intravenous catheters were placed into each external jugular vein, the mammary gland was completely evacuated following 5 IU of oxytocin given intravenously and the urinary bladder was emptied. On the first day isotonic saline was rapidly infused intravenously and blood, milk, and urine samples were collected sequentially for 8 hours post-infusion. Blood and milk were sampled together, however, milk samples were collected from one quarter only during each sampling period and the quarters were sampled sequentially. Oxytocin (5 IU) was given intra-

venously each sampling time and all milk removed from the respective quarter by hand milking. On the second day an equal volume of urea solution was infused to provide 130 mg of urea per kilogram of body weight and the same sampling protocol was repeated. Blood, milk and urine samples from both days were analyzed for urea nitrogen concentration using the diacetyl monoxime dye assay manufactured by Sigma (kit# 535).

A model to account for urea movement was developed using the SAAM/CONSAM program. A two compartmental model was needed to account for the shape of the plasma response curve. All losses of urea from the system were accounted for in milk and urine.

Results.

Milk urea and milk volume excretion were compatible with passive transfer of urea from plasma to milk along with water. Urine data was not compatible with passive transfer of urea from plasma into urine and reflected the ability of the kidney to concentrate urea in urine. No partitioning of urea from water is evident in the mammary gland. Urea concentrations in milk are a result of plasma urea concentrations.

Experiment 2: Influence of Protein Feeding on Milk Urea

Materials and Methods.

Four multiparous Holstein cows were used in a 4 X 4 Latin square design with two week periods to investigate the effects of protein concentration, protein degradability and protein quality on plasma urea concentration and milk N constituents. Diets contained 34% corn silage, 19% alfalfa haylage, and 49% concentrate (dry matter basis). Concentrates varied in amounts of urea and soybean, corn gluten, fish and blood meals.

Diets varied in crude protein (CP) concentration and in the amount and proportion of rumen degradable (DIP) and undegradable (UIP) protein relative to NRC recommendations: A) balanced for CP, excessive DIP, deficient UIP; B and C) balanced for CP, DIP and UIP; D) excessive in CP and DIP, balanced for UIP. Diets also varied in protein quality. Only diet C formulated with blood meal and fish meal provided an adequate supply of methionine and lysine to the small intestine as predicted by the Cornell Net Carbohydrate and Protein System. All other diets were 10-12% deficient in methionine and 18-20% deficient in lysine.

Daily feed weights were obtained and feed samples were composited during the second week of each period and analyzed for nutrient composition and protein degradability. Milk samples were collected during morning and evening milkings and composited for the last 3 days of each period. Milk was analyzed for total N, NPN, MUN, and fat content. Blood was collected morning and evening and plasma was analyzed for urea N content.

Results.

Dry matter intake was not significantly different between diets. Intakes of DIP and UIP were compatible with dietary formulation goals. Concentrations of BUN and MUN were compared within cow and sample day and were found to be highly correlated (r=.96).

Diet D which was excessive in dietary CP resulted in the highest blood and milk urea nitrogen concentrations of 23 mg/dl (Table 1). Diet A balanced for CP with imbalances in DIP and UIP produced urea concentrations of 18 mg/dl which were significantly lower than diet D but significantly higher than 16 mg/dl produced on isonitrogenous diets B and C balanced for DIP and UIP (Table 1).

Milk nonprotein nitrogen (NPN) concentrations also varied between diets similarly to MUN concentrations (Table 1). Differences in NPN concentration were attributed to differences in MUN concentration.

Milk yield and fat content were not significantly affected by diet. Milk crude protein (CP) content was significantly higher on diets B and C (3.2%) as compared to diets A and B (3.1%). True protein was calculated as the difference between milk CP and NPN content. Undegraded intake protein and amino acid balance influenced milk true protein content: A) 2.89%[a] B) 2.90%[ab] C) 3.01%[c] D) 2.95%[b]. Diet C balanced for DIP and UIP using high quality protein sources resulted in significantly higher true protein content as compared to all other diets (P < 05). The ratio of true protein to urea was largest to smallest on diet C (32[a]), B (29[b]), A (25[c]), and D (20[d]).

Discussion

Urea concentration in milk is dependent upon the plasma urea concentration. Plasma urea concentration within cows varies daily related to feed intake and other factors. Milk accumulates urea and water from the plasma until the mammary gland is emptied and the accumulation begins again. Milk urea concentration is an integration of various plasma urea concentrations occurring between the last milking and the time when the milk is sampled. Since milk captures the variation in plasma urea concentrations milk urea concentration would be an ideal indicator of the average plasma urea concentration occurring during the interval between sampling and the last milking.

Milk urea concentration appears to be very sensitive to imbalances in CP, DIP and UIP. Concentrations of MUN reflect protein wastage and could be used to assess dietary protein supply. Milk true protein content is influenced by amino acid supply. The proportions of true protein and urea in milk reflect efficiency in N utilization and ration formulation. To obtain milk which is relatively high in true protein and low in urea diets need to be balanced for CP, DIP and UIP using high quality protein sources.

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Table 1.

Urea Response to Protein Imbalances			
• = nutrient balance			
+ = nutrient excess			
- = nutrient deficiency			
		Diet	
Protein Balance	A	B	C	D
CP	•	•	•	+
DIP	+	•	•	+
UIP	-	•	•	•
AA	-	-	•	-
BUN mg/dl	18.5[a]	16.4[b]	16.0[b]	23.4[c]
MUN mg/dl	18.6[a]	15.6[b]	15.1[b]	23.3[c]
Milk NPN mg/dl	33.6[a]	31.2[b]	30.3[c]	39.0[d]
a b c = Unlike row superscripts differ (P < .05)			