RELATIONSHIP AMONG CONCENTRATIONS OF MILK UREA NITROGEN AND PLASMA UREA NITROGEN AND FEEDING TIME

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Summary

Eight Holstein cows were used to determine the relationship among milk urea nitrogen (MUN), plasma urea nitrogen (PUN), and feeding time. We first established that MUN concentrations were similar in concentration among quarters by comparing milk samples from each quarter just before milking. In order to determine if collecting a sample of milk from a quarter influenced the MUN in samples taken later, samples were obtained from the right front quarter (RF) at 2, 4, 6, and 8 hr after the AM milking and from the left front quarter (LF), right rear (RR), and left rear (LR) at 4, 6, and 8 h after the AM milking, respectively. The MUN in samples obtained from RF at 4 hr was lower ($P<0.01$) than corresponding samples taken from LF, but samples from RF at 6 and 8 hr did not differ from corresponding samples obtained from RR and LR. We concluded that by 6 hr, the effect of previous milking on MUN concentration disappeared because of dilution. To determine the influence of feeding time on MUN concentrations, cows were fed half of their normal PM feeding, injected with oxytocin at the subsequent AM milking to reduce residual milk, and offered surplus feed after the AM milking. Milk samples were collected at 2, 4, 6, 8, 10, and 12 hr after feeding from RF, LF, RR, LR, RF, and LF quarters, respectively. Blood samples were obtained from the coccygeal vein at hourly intervals after feeding with the last sample collected 12 hr after feeding. The MUN concentrations at 2, 4, 6, and 8 hr were similar. The MUN at 10 hr was similar to those at 2 and 8 hr, less than that at 4 and 6 hr, and greater than that for the 12 hr sample. Concentrations of PUN peaked at 2 hr postfeeding, then gradually declined through 12 hr postfeeding. The MUN peaked at 6 hr postfeeding and then declined. Time after feeding significantly influenced PUN and MUN concentrations.

(Key Words: MUN, PUN, Feeding Time.)

Introduction

Crude protein in dairy cow diets consists of ruminally degradable and undegradable fractions. Ruminal microbes utilize degradable protein to meet their requirements. A portion of this degradable protein appears in the lower tract as microbial protein that can be digested, absorbed, and utilized by the cow's body. Undegradable protein passes through the rumen and can be digested and absorbed in the lower tract. The optimal amount of each protein fraction to include in the diet is influenced by the amount of milk produced. Milk production dictates the amount of metabolizable protein required and influences total feed intake by the cow. Ruminally degradable protein and carbohydrates in the diet influence the efficiency by which rumen microorganisms incorporate dietary rumen degradable protein into microbial protein. Generally, the efficiency of protein utilization in the rumen decreases as protein intake increases or the microbial population decreases. One method of evaluating protein utilization in the rumen is to measure plasma urea nitrogen (PUN), a by-product of ammonia clearance from the blood. This detoxification event occurs in the liver, where amine groups are bonded to form urea for excretion primarily in the urine. Urea also is recycled back into the rumen via the salivary glands or excreted in the milk. The urea nitrogen in milk (MUN) is correlated highly with that in blood. Thus,

MUN provides a convenient method of estimating PUN.

Feed intake and dietary content of ruminally available protein and rumen soluble carbohydrates affect MUN. Changes in dietary ingredients that result in more or less ruminally available protein, carbohydrates or both usually increase or decrease MUN if feed intake remains relatively constant. Protein not used by the cow contributes to unnecessary feed costs and excretion of nitrogen into the environment. Concentrations of MUN provide a convenient method to evaluate efficiency of nitrogen utilization among diets. The objective of this study was to determine the influence of feeding time on MUN and PUN concentrations.

Procedures

Eight Holstein cows past peak daily milk production were housed and fed in tie-stall facilities at the Kansas State University Dairy Teaching and Research Center, Manhattan. Diets were formulated to meet or exceed NRC (1989) recommendations. Cows were fed a total mixed ration with alfalfa hay and corn silage as the forages and corn as the cereal grain. Whole cottonseed and mechanically extracted soybean meal were used as the primary sources of supplemental fat and protein. Diets were formulated to contain .78 Mcal NEL/lb dry matter, 17% crude protein, 40% nonfiber carbohydrate, 6.8% rumen undegradable protein, and 10.2% rumen degradable protein on a dry matter basis. Cows were moved into the tie-stall barn 3 days before the beginning of Experiments 1 and 2 and 10 days before Experiment 3. Averages for daily dry matter intake (DMI), crude protein intake (CPI), milk production, energy-corrected milk (ECM), and MUN/lb DMI for the 11-d experimental period are shown in Table 1. Milk samples were analyzed by the Heart of America DHI Laboratory, Manhattan, KS.

Experiment 1

The objective of this experiment was to determine whether quarter samples collected before complete milk-out accurately reflect the MUN concentrations of the total milk in the mammary glands and whether MUN values vary among quarters.

At the AM milking, milk samples were obtained from each quarter before attaching the milking machine, and a composite sample was taken from the weigh jar after milking. Milk samples were analyzed for concentration of fat, protein, solids-not-fat (SNF), lactose, somatic cell count (SCC), and MUN.

Experiment 2

This experiment was conducted to determine if the process of collecting milk from a quarter influenced the MUN concentrations in samples obtained from the same quarter at 2, 4, 6, and 8 hr after milking. Sampling procedures consisted of predipping the teat, wiping the dip off, removing three to five squirts of milk, and collecting the sample. Milk samples were obtained from the right front (RF) quarter 2, 4, 6, and 8 hr after the AM milking. Milk samples were collected from the left front (LF) quarter at 4 hr after the AM milking, the right rear (RR) quarter at 6 hr after the AM milking, and the left rear (LR) quarter 8 hr after the AM milking.

Experiment 3

Experiment 3 was conducted after results of experiments 1 and 2 were known. The objective of this experiment was to determine the influence of feeding time on concentrations of MUN and PUN.

Cows were limit fed the night before the experiment to encourage intake the next morning. At the AM milking, cows were injected with 80 IU of oxytocin to remove residual milk. Cows were fed immediately following milking. Milk samples were collected at 2, 4, 8, 10, and 12 hr after feeding from the RF, LF, RR, LR, RF, and LF quarter, respectively. Samples were analyzed for fat, protein, SNF, lactose, SCC, and MUN. Blood samples were collected from the coccygeal vein beginning 1 hr after feeding and at hourly intervals thereafter, with the last sample collected 12 hr after feeding. Plasma was separated immediately and

frozen until analysis for glucose, total alpha amino nitrogen (TAAN), and PUN.

Results

Experiment 1

The MUN concentrations in milk samples collected immediately before complete milk-out were not different among individual quarters. Urea nitrogen in milk from quarters, except the RF, differed ($P<0.05$) from that of the composite sample (Table 2). Percentages of milk fat were similar among quarters, but were greater in the composite sample ($P<0.05$) than in the quarter samples. Milk protein percentages among individual quarters did not differ, but were greater in samples from RF and LF than in the composite sample. Percentages of solids-not-fat and lactose in milk were not different among individual quarter and composite samples. Fewer ($P<0.05$) somatic cells were detected in milk from LF than milk from LR, but counts were similar among other quarters and the composite (Table 2).

Experiment 2

The MUN concentrations in samples taken from the RF at 4 hr after complete milk-out and 2 hr after the first sample were lower ($P<0.01$) than those in samples taken from LF at 4 hr (Table 3). Samples obtained at 6 and 8 hr after milking contained similar concentrations of MUN among quarters sampled.

Experiment 3

Variation in milk composition over time after feeding is shown in Table 4. Milk urea nitrogen peaked at 6 hr postfeeding and decreased linearly ($P<0.01$) through 12 hr postfeeding (Figure 1). Concentrations of MUN in milk samples obtained at 2, 4, 6, and 8 hr after feeding were numerically, but not significantly ($P>0.05$), different. Samples at 4 and 6 h were different. The 12 h postfeeding sample contained less ($P<0.01$) MUN than other samples. Milk fat percentages decreased linearly ($P<0.01$) over time, whereas percentages of milk protein, SNF, and lactose increased linearly ($P<0.01$) over time.

The PUN concentration peaked at 2 hr postfeeding (15.77 mg/dL), then declined to 10.65 mg/dL at 12 hr postfeeding (Figure 1). A linear ($P<0.01$) relationship was observed between PUN and time after feeding; however, PUN concentrations were not different between samples taken 1, 2, 3, and 4 hr after feeding. Average PUN and MUN values for the 12 hr period were similar, 13.4 mg/dL and 13.6 mg/dL, respectively. Plasma glucose (Table 5) was lowest (67.43 mg/dL) at 3 hr postfeeding, highest at 9 hr postfeeding, similar among other sampling times, and best described by a quadratic contrast ($P<0.01$). Plasma TAAN was not influenced by time after feeding (Table 5).

Discussion

The primary objective of this study was to determine the influence of feeding time on concentrations of MUN and PUN. However, sampling techniques had to be verified before this could be accomplished. First, we had to establish that MUN concentrations were similar among individual quarters and that quarter sample values accurately reflected values obtained from a milk sample obtained after complete milk-out of the entire udder (composite sample). Results from Experiment 1 demonstrated that MUN concentrations were similar among quarters and those from all quarters except one differed from the composite sample. However, the concentrations in the three quarter samples and the composite were within 0.5 mg/dL and would not affect management decisions concerning the diet.

The second factor to evaluate was whether prior sampling influenced the MUN value of a later sample. The results from Experiment 2 indicated that MUN concentrations were affected in samples obtained less than 4 hr after a quarter was first sampled. The sampling procedure in Experiment 3 allowed adequate time (6 hr) between samples from the same quarter for dilution, thereby negating effects of previous samplings from the quarter.

Because most producers obtain milk samples for MUN analysis at either the AM or PM milking, but not both, feeding time before each milking may not be the same. In addition, when cows are milked by groups, milking time following feeding may vary among groups. Results from Experiment 3 indicate that sampling time after feeding alters MUN and PUN concentrations. Concentrations of MUN peaked at 6 hr postfeeding and declined through 12 hr postfeeding. Therefore, sampling milk for MUN concentration, without regard to feeding time, can affect the results and lead to incorrect interpretations.

Conclusions

Because time of sampling postfeeding affects MUN and PUN concentrations, it must be considered when interpreting results and making feeding decisions. According to our results, milk should be sampled at 6 hr postfeeding in order to obtain the peak MUN concentration. On the farm, MUN values obtained from samples taken at the AM milking in one test period and the PM milking in the next test period will vary, if feeding time before milking varies. This is important for evaluating responses of cows to diet changes that may have occurred during the month. Furthermore, MUN concentrations should not be compared among groups when their feeding times prior to milking vary. Time after feeding also should be considered when sampling for PUN. Samples obtained at 2 hr postfeeding reflect peak ammonia clearance from the blood.

Information gained from this study will assist producers in the interpretation of MUN data collected from their herd. Diet changes designed to increase the efficiency of nitrogen utilization by the dairy cow depend on correct interpretation of data routinely available to the producer.

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Table 1. Average DMI, CPI, Milk, ECM, and MUN/kg DMI

Item	Average[1]	Exps. 1 and 2[2]	Exp. 3[3]
DMI, lb/day	49.65	47.94	56.52
CPI, lb/day	8.45	8.14	9.61
Milk, lb/day	62.79	62.48	65.21
ECM[4], lb./day	67.54	65.67[5]	—
MUN/kg DMI	—	.25[5]	.21[6]

[1]Average for the 11 d observation period.

[2]Average for day samples taken for Exps. 1 and 2.

[3]Average for day samples taken for Exp. 3.

[4]ECM = energy-corrected milk.

[5]Calculated from composite sample values.

[6]Calculated from 12 hr values.

Table 2. Relationship among Quarters with Respect to Milk Composition

	Quarter				
Item	RF	LF	RR	LR	Composite
Fat, %	1.54[a]	1.44[a]	1.61[a]	1.52[a]	3.59[b]
Protein, $	3.65[ab]	3.68[a]	3.68[a]	3.63[ab]	3.60[b]
SNF, %	9.42[a]	9.51[a]	9.48[a]	9.34[a]	9.39[a]
Lactose, %	4.99[a]	5.04[a]	5.00[a]	4.94[a]	4.98[a]
SCC, *1000	62.00[ab]	29.13[a]	77.38[ab]	134.63[b]	63.25[ab]
MUN, mg/dl	12.25[ab]	12.48[a]	12.45[a]	12.49[a]	12.06[b]

[a,b]Means within rows sharing different superscript letters differ ($P<0.05$).

Table 3. Effect of Previous Sampling on MUN Concentration (mg/dL)

	Sampling Time, hr			
Quarter	2	4	6	8
RF	11.27	12.22[a]	13.04	13.11
LR	–	12.81[b]	–	–
RR	–	–	12.76	–
LR	–	–	–	13.07

[a,b]Values within columns sharing different superscript letters differ ($P<0.01$).

Table 4. Variation in Milk Composition over Time after Feeding[1]

	Time Postfeeding, hr						
Item	2	4	6	8	10	12	Contrast[2]
Fat, %	7.66	6.37	5.32	4.12	2.27	2.22	linear
Protein, %	3.06	3.26	3.44	3.62	3.93	4.00	linear
SNF, %	8.04	8.23	8.35	8.57	9.03	9.23	linear
Lactose, %	4.22	4.23	4.20	4.25	4.41	4.53	linear
SCC, *1000	956.38	438.88	1135.25	763.25	519.63	369.63	–
MUN, mg/dL	13.65	14.30	14.46	13.94	13.16	12.04	linear

[1]Feeding time began approximately 30 min after AM milking.
[2]$P<0.01$.

Table 5. Effects of Time after Feeding on Plasma Metabolites

Sampling Time	PUN[1a], mg/dL	TAAN[2], mmol/L	Glu.[3b], mg/dL
1	15.17	2.41	71.1
2	15.77	2.19	70.6
3	15.66	2.11	67.4
4	15.39	2.12	70.2
5	14.80	2.06	71.7
6	13.95	1.91	72.0
7	13.15	1.99	72.3
8	12.25	1.99	72.8
9	11.71	2.03	73.9
10	11.24	2.06	70.1
11	10.99	2.24	72.9
12	10.65	2.15	71.3
SEM	.25	.05	.84

[1]Plasma urea nitrogen
[2]Total alpha amino acid nitrogen
[3]Glucose.
[a]Linear contrast ($P<0.01$).
[b]Quadratic contrast ($P<0.01$).

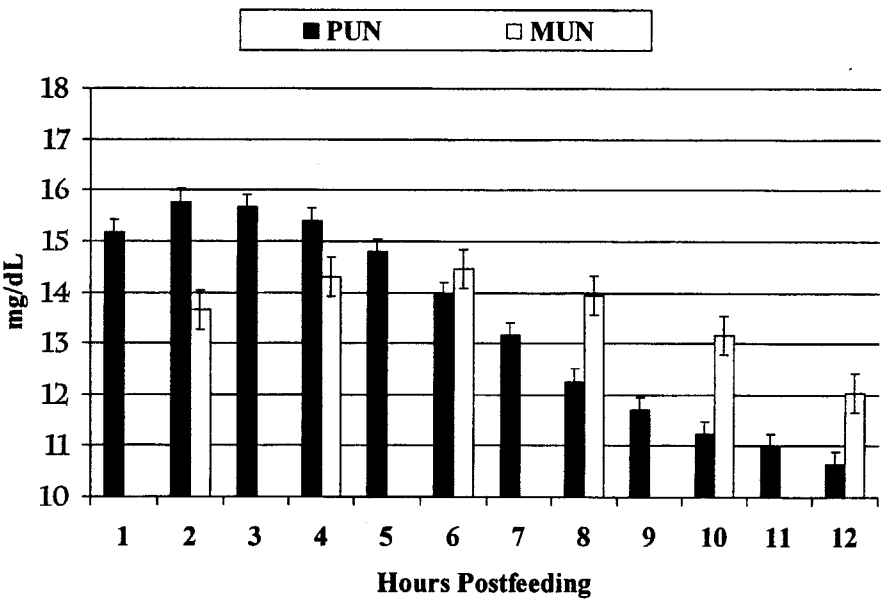

Figure 1. Effects of Time Postfeeding on MUN and PUN.