Use of Milk Urea as an Indicator of Nitrogen Utilization in the Lactating Dairy Cow

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Introduction

Urea is the primary form in which N is excreted in mammals; therefore, elevated blood urea is related to inefficient utilization of dietary CP. Concentrations of milk and blood urea are highly correlated (Oltner and Wiktorsson 1983, Gustafsson and Palmquist 1993) and milk urea N (MUN) serves as an easily sampled indicator of blood urea N (BUN). Milk urea N has attracted attention as a possible index of excessive ruminal protein degradation. Hutjens and Barmore (1995) suggested MUN in the range of 12 to 17 mg N/dL would indicate optimal balance of RDP and ruminally fermentable energy. Since 1978, we have measured MUN in feeding trials with lactating cows. The objective here was to use these data to study the relationship of MUN to a number of variables related to diet, protein yield and N efficiency.

Materials and Methods

Concentrations of MUN were measured in 22 feeding trials using 419 lactating cows fed 78 different diets; these were conventional production trials in which intakes of DM, CP and estimated NE_L, change of BW, BUN concentrations, and production of milk, fat, protein and lactose were determined. In 16 of the trials, 76 ruminally cannulated cows were used in switch-back arrangements of treatments to quantify ruminal ammonia on 56 of these diets. In 10 of the trials, fecal grab samples were taken from 203 lactating dairy cows fed 38 diets and internal markers (either acid insoluble ash or indigestible ADF) used to determine digestible DM and to compute NE_L assuming digestible DM was equivalent to TDN. Concentrations of MUN and BUN were determined in all trials using a diacetyl monoxime colorimetric assay adapted to Technicon AutoAnalyzers. All of these data already are published in seven papers and two theses. Linear regression of MUN on each variable studied was used to assess the relationships.

Results and Discussion

Table 1 lists 16 equations obtained from linear regression of MUN level (mg N/dL) and, in one case, MUN secretion rate (mg N/d) on nine different variables. Regressions for the eight variables that were derived from the complete data set (equations 1 through 8) were significant ($P > .001$). The highest correlation was obtained from regressing MUN on BUN (equation 1; $r^2 = .743$); Gonda and Lindberg (1994) reported a correlation coefficient of .73 for MUN and BUN. The strong relationship between MUN and BUN is illustrated in Figure 1. An interesting finding was that MUN was not nearly as well correlated to ruminal ammonia concentration (equation 9; $r^2 = .429$; Fig. 2) as it was to a number of factors related to dietary CP and N efficiency. Milk urea N was more highly correlated to dietary CP content (equation 2; $r^2 = .588$) than to CP intake (equation 5.1; $r^2 = .439$). Amount of MUN secreted (mg N/d) was more poorly correlated than MUN concentration for every variable except for CP intake (equation 5.2; $r^2 = .601$). Concentration of MUN was correlated similarly to N efficiency (milk N:N intake; equation 7) and to excess N intake (N intake minus milk N; equation 8); both explained about 55% of the variation in MUN concentration. These results indicated that MUN may be more useful as an index of overall N inefficiency than as an index of excessive ruminal protein degradation. Solving regression equation 7 (Fig. 3) for the MUN corresponding to the average N efficiency from all 78 diets (milk-N:N-Intake = .243) yielded a MUN estimate of 16.1 mg N/dL; MUN greater than this would imply a N efficiency of less than 24%.

Using data from all 78 diets, correlation of MUN to dietary content and intake of NE_L, computed from NRC tables (nNE_L, equations 3 and 4), was not as strong as it was to the variables derived from dietary CP. The ratio, dietary CP/nNE_L, also was not as well related to MUN as was dietary CP alone. Dietary NE_L content and intake also were estimated from digestible DM (dNE_L) on 38 of the diets. On these diets, MUN was not significantly correlated ($P > .06$) to intake of either nNE_L or dNE_L (equations 10 and 11). However, CP/dNE_L was more highly correlated to MUN (equation 13.1; $r^2 = .650$) than was CP/nNE_L (equation 12.1; $r^2 = .564$). Inspecting the regression of MUN on CP/dNE_L (Fig. 4) suggested that data from one diet, which contained 81% autoclaved alfalfa hay, was an outlier; deleting this point substantially improved the fit of this regression (equation 13.2; r^2 = .727) as well as the regression of MUN on CP/nNE_L (equation 12.2; r^2 = .654).

Conclusions

Concentration of MUN was highly correlated to BUN and dietary CP/dNE_L (NE_L estimated from digestible DM). Milk urea N was more highly correlated to N efficiency than to ruminal ammonia concentration; MUN explained 55% of the variation in N efficiency in this data set. Scatter of data for the regression of MUN on N efficiency was similar for efficiencies ranging from 16 to 30%. Although MUN concentration will be a useful index of CP utilization, specific MUN values are only approximate guidelines to the protein status of the lactating cow.

References

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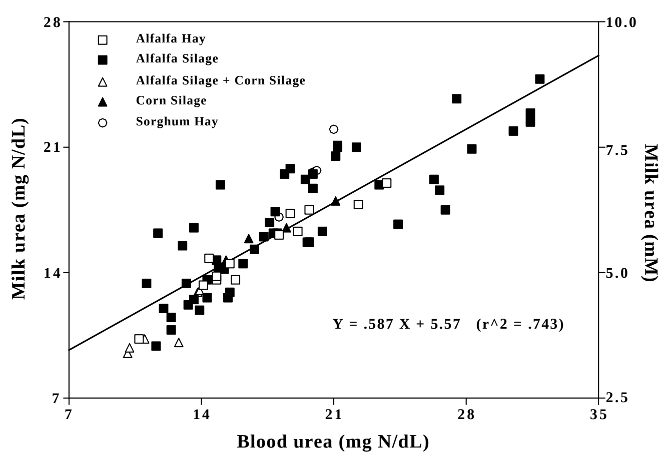

Figure 1. Regression of milk urea N concentration on blood urea N concentrations observed in 419 lactating dairy cows fed 78 diets in 22 different trials.

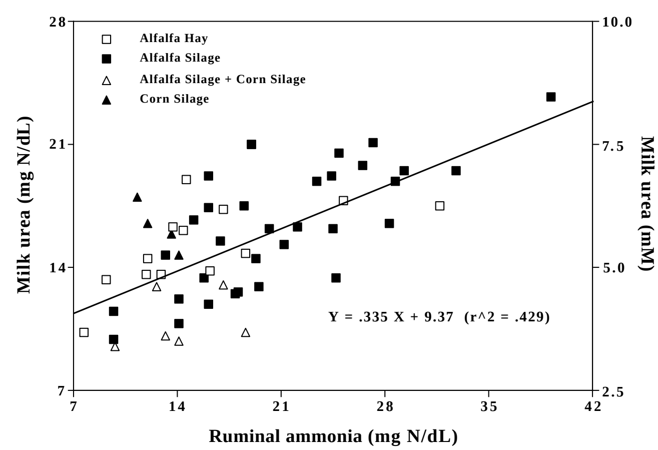

Figure 2. Regression of milk urea N concentration on ruminal ammonia concentrations observed in 76 ruminally cannulated lactating dairy cows fed 56 diets in 16 different trials.

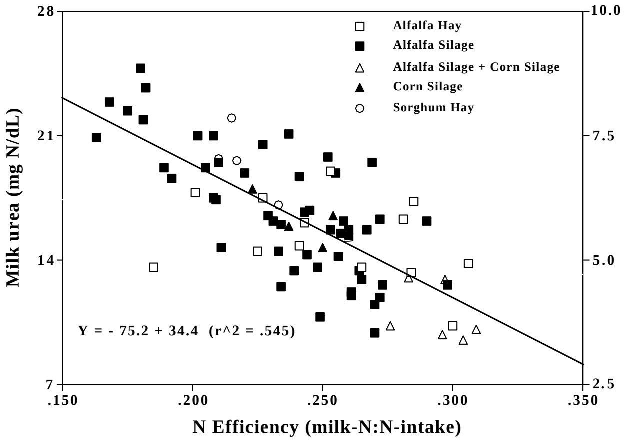

Figure 3. Regression of milk urea N concentration on N efficiencies (milk N:N intake) observed in 419 lactating dairy cows fed 78 diets in 22 different trials.

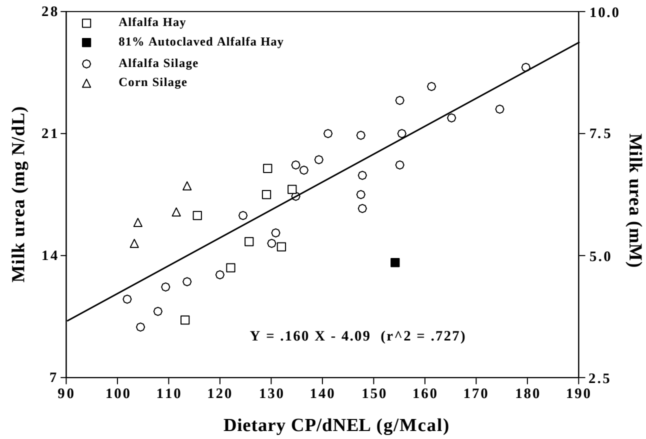

Figure 4. Regression of milk urea N concentration on the ratios CP/dNE$_L$ (computed from digestible DM) observed in 203 lactating dairy cows fed 38 diets in 10 different trials.

Table 1. Linear regression equations.[1]

X-variable	Eq. no.	Equation	n	r^2	$P > F$[2]
Blood urea N, mg N/dL	1	Y1 = .587 X + 5.57	78	.743	< .001
Dietary CP, % of DM	2	Y1 = 1.37 X - 8.48	78	.588	< .001
Dietary nNE$_L$, Mcal/kg DM	3	Y1 = - 16.8 X + 42.9	78	.198	< .001
Dietary CP/nNE$_L$, g/Mcal	4	Y1 = .147 X - .558	78	.529	< .001
CP intake, kg/d	5.1	Y1 = 4.74 X - 3.03	78	.439	< .001
	5.2	Y2 = 188 X - 250	78	.601	< .001
nNE$_L$ intake, Mcal/d	6	Y1 = - .216 X + 23.9	78	.058	.033
N efficiency (milk N:N intake)	7	Y1 = - 75.2 X + 34.4	78	.545	< .001
Excess N intake (N intake - Milk N), g/d	8	Y1 = .0342 X - .696	78	.552	< .001
Ruminal NH_3, mg N/dL	9	Y1 = .335 X + 9.37	56	.429	< .001
Dietary nNE$_L$, Mcal/kg DM	10	Y1 = -3.59 + 11.7	38	.093	.063
Dietary dNE$_L$, Mcal/kg DM	11	Y1 = - 3.14 X + 10.5	38	.046	.084
Dietary CP/nNE$_L$, kg/Mcal	12.1	Y1 = .135 X + .700	38	.564	< .001
	12.2[2]	Y1 = .147 X - .559	37	.654	< .001
Dietary CP/dNE$_L$, g/Mcal	13.1	Y1 = .150 X - 3.03	38	.650	< .001
	13.2[2]	Y1 = .160 X - 4.09	37	.727	< .001

[1]Y1 = Milk urea N Concentration (mg N/dL); Y2 = milk urea N secretion rate (mg N/d); nNE$_L$ = NE$_L$ computed from ration composition using NRC tables; dNE$_L$ = NE$_L$ computed from ration digestible DM determined using fecal marker ratio techniques, assuming digestible DM = TDN; n = number of diets used in the linear regression.

[2]Regressions obtained after deleting data from one diet that contained 81% of DM as autoclaved alfalfa hay.