Analysis Of The Significance Of Urea Nitrogen Levels In Milk And Blood In Dairy Cattle

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Abstract

The determination of urea nitrogen levels in blood and milk is considered an alternative to determining the protein balance of dairy cattle. The ratio of rumen-degradable and non-rumen-degradable proteins is the origin of ammonia production, which is transformed into urea by the liver, circulates in the blood, and is partially excreted in the milk. The detoxification of ammonia constitutes a loss of energy for the dairy cow which limits milk production. The use of Yucca shidighera plant extract helps to retain the ammonia released in the rumen and increases its utilization by the microflora, limiting the increase of urea nitrogen in blood and milk.

Keywords: urea nitrogen, milk, blood, dairy cattle, Yucca shidighera.

Introduction

There is a relationship between blood and milk urea nitrogen levels (NUS and NUL) in dairy cattle, dependent on the degradability of different protein sources and nitrogen compounds. The N.R.C. (18) gives recommendations for dairy cows of an intake ratio of approximately 73% of rumen degradable protein and 37% non-rumen degradable or "passant" protein for the early stages of lactation. Both excess protein in the ration and high levels of degradable protein leads to a high concentration of ammonia in the rumen, which is partially utilized by the microflora. This leads to increased urea synthesis and high levels of urea in the body fluids, which are recycled via saliva. Unused urea is excreted in urine and milk. The level of circulating non-protein nitrogen is of significance because of its consequent effect on reproductive behavior (11) and the integrity of the liver and mammary tissues (2). These values provide a simple tool to assess the efficiency of dietary protein utilization.

Importance of blood and milk nitrogen levels

Nitrogen metabolism in ruminants involves the active participation of the microflora and the utilization of protein degradation products for bacterial protein synthesis. Unused ammonia in the rumen is transported to the liver and tissues for conversion to urea. The use of high protein and non-protein sources of nitrogen in dairy cow diets affects mammary gland condition by increasing somatic cell counts and the incidence of mastitis. Values outside those considered as normal indicate nutritional imbalances that can have important economic and productive significance.

Rumen activity on nitrogen compounds

A large part of the nitrogen compounds in the diet is converted to ammonia in the rumen by bacterial degradation, which is then used by these microorganisms for protein synthesis, depending on multiple nutritional factors. Unused ammonia is absorbed through the rumen epithelium and transported via the portal route to the liver.

An excess of ammonia in the rumen indicates that its production is greater than the capacity of the ruminal microorganisms to transform it into microbial protein or that the existing microflora is unable to utilize ammonia at the rate of its production. Ammonia detoxification imposes significant enzymatic activity at the liver level, involving modification of plasma levels of ornithiol carbamyl transferase (OCT) (Table 1). This detoxification, in turn, requires energy consumption, which is always important, but more critical in the case of high-producing dairy cows at the beginning of lactation. This conversion costs the animal of about 12 kcal/g of nitrogen. Using a Cornell University model and considering a NUL reading of 20 mg/dL, it was estimated that there would be a reduction in milk production equivalent to about 3.5 L per day, due to the amount of energy that would be used for the synthesis of urea from ammonia and could not be used to produce milk.

In feeding trials with dairy cows (where each animal was in control of itself for each treatment) fed balanced rations (Control), with treatments replacing part of the dietary protein with a mixture of molasses-urea-phosphoric acid (Urea) (1), and with the addition of a rapidly utilized energy source such as glucono-delta-lactone (GDL) (6), the influence of ammonia on several parameters related to nitrogen utilization was demonstrated.

Blood ammonia levels are generally kept low because the liver rapidly converts ammonia to urea (ornithine cycle). If ammonia production exceeds the liver's ability to convert ammonia to urea, blood ammonia levels may become toxic. In fact, urea, like nitrates, is not toxic in itself.

High levels of ammonia in the blood influence appetite, thus limiting food intake and rarely reaching acute toxicity, however, its constant presence at high levels causes permanent sub-optimal production situations.

Work in New York and Pennsylvania has shown that high levels of NUS can reduce conception rates due to negative energy balance, increased uterine acidity, and changes in the ratio of minerals lining the uterus (5, 8). In addition, high levels of NUS have been linked to liver problems and delayed onset of the first oestrus. Several scientific papers relate dietary crude protein levels to NUS levels and conception rates (Table 2). Although crude protein should not be considered an independent entity, as it is related to solubility and energy availability levels in the diet, table 2 serves to illustrate the concept.

Table 1. Blood urea nitrogen (NUS), ornithine carbamyl transferase (OCT) and glutamic oxaloacetic transferase (SGOT) levels in dairy cows fed rations containing non-protein nitrogen (Urea) and energy sources (GDL).

Treatment	NUS(a)	OCT(b)	SGOT(c)
Control	12,57	137,7	57,29
Urea	16,46	245,5	56,83
Urea + GDL	17,54	227,6	61,83

(a) mg per 100 mL. (b) Sigma-Frankel units of OCT (c) Sigma-Frankel units of SGOT.

Research in Maine showed that high protein levels can affect health and the immune system, especially in cows with postpartum problems. These results are consistent with work in Pennsylvania, where research reported a higher incidence of positive bacterial cultures of Streptococcus agalactie and Staphylococcus haemoliticus in milk from urea-supplemented cows, requiring 37% more treatment for mastitis, which correlated with significantly ($P<0.01$) higher California Mastitis Test CMT results (19) for cows fed non-protein nitrogen rations. In those studies, they reported that urea excretion in milk was 38.33 mg per 100 mL for the control ration and 48.41 mg per 100 mL for the urea-supplemented ration. This factor is important for the quality of milk used for cheese production, which is reduced due to high levels of non-protein nitrogen.

Many countries already have or are about to have, milk payment systems based on true protein content with penalties for high urea nitrogen milks. Switzerland and France already have a NUL penalty scheme, and the UK is likely to follow this trend.

High levels of UAN and ULN will also have an impact on the environment because excess nitrogen excreted in urine and feces can affect water quality and increase environmental odors.

In addition to the productive and ecological factors mentioned above, from an economic point of view, high levels of NUL indicate dietary imbalances and energy losses with increased feed costs.

Table 2. Conception rates (CT) and blood urea nitrogen (NUS) concentration of lactating cows fed moderate and high crude protein (CP) diets.

% of CP in the diet				
	15 - 16		19 - 21	
Reference	CT (%)	NUS (mg%)	CT (%)	NUS (mg%)
Jordán y Swanson (1, 2)	53	NI (4)	40	NI
Folman et al. (9)	56	8,8	44	15,4
Kaim et al. (16)	57	9,0	43	17,0
Howard et al. (13)	87	15,0	85	26,0
Carroll et al. (5)	64	11,0	56	24,0
Bruckental et al. (3)	65	25,0	52	32,0
Canfield et al. (4)	48	12,0	31	19,0
Elrod & Butler, (7)	83	<16,0	62	>16,0
Averages	62	13,8	48	21,3

(1) sobre vacas concebidas; (2) P<0,05; (3) primer servicio; (4) no informado.

Suspecting dietary imbalances

Periodic assessment of NUS/NUL levels will help to estimate the nutritional status of the herd and to prevent possible nutritional imbalances. The following are some practical observations that will help to monitor NUS/NUL values more closely:

Animals grazing on new, fast-growing spring pastures, or grazing on fast-growing annual crops. Animals on diets based on conserved forage from perennial or annual fast-regrowth pastures.

Dietary changes in rumen undegradable/degradable protein levels.

Conception rates below herd historical rates.

Changes in feed particle size, especially maize, and other grains.

Low milk protein values.

Another good practical relationship indicates that NUL values represent between 83 and 98% of NUS values. It is accepted that dividing NUL by 0.85

gives a good estimate of NUS. NUL levels have been related to their physiological effects on ruminants, as shown in Table 3.

Table 3. Physiological effect on ruminants according to NUL levels

NUL, mg/dL	Risk
> 15,4	Pathological
12,6 - 15,4	High risk
8,4 - 12,6	Normal
5,6 - 8,4	Low risk
<7,0	Low protein and/or low carbohydrate

Preventing increases in NUS/NUL

Proper rumen balance of soluble and insoluble proteins can prevent ammonia excesses that increase NUS/NUL, but this is not always an easy task. Two situations are especially difficult: highly fertilized pasture silages or high-quality legume silages and fast-growing spring pastures.

An extract from the desert plant Yucca shidighera has the property of sequestering ammonia and other gases, providing in this case, a means of retaining ammonia in the rumen, where it can be utilized by the microflora, thus helping to prevent NUS and NUL increases.

Recent research in Ireland showed that, where the non-protein nitrogen content of silage and pasture combined to create fertility problems in high-producing cows, the use of the commercial plant extract product Yucca shidighera (Table 4) in the diet reduced NUL. Cows in this experiment were stabled and fed a ryegrass silage-based diet for the first 14 days, followed by grazing on fast-growing spring gramineous pastures. The addition of Yucca shidighera extract to the diet reduced NUL by 20% in animals fed silage and pasture.

Further evidence of the effectiveness of using cassava extract to reduce plasma and rumen ammonia levels has been demonstrated by Hussain and Cheeke (12) working on steers. They studied the effect of Yucca extract under two types of constant diets. One included high levels of concentrates, the other was based on high fibre. In addition, two different protein sources, soybean meal, and urea, were used.

In the case of a high-fibre diet (table 5), supplementation with Yucca extract reduced rumen ammonia content by 11% when soybean meal was used as a protein supplement, and by 15% when urea was used as a nitrogen source. Plasma urea nitrogen was higher when Yucca shidighera extract was added to soybean feed, while the opposite was true when urea was used as a nitrogen source.

Table 4. Effect of Yucca shidighera extract (*) on NUL levels (mg/L) in housed and grazing dairy cows.

	Control	Yucca shidighera
Stable day 0 (Pre-treatment)	175	175
Stable day 14 (2nd reading)	169	142
Pasture day 15 (3rd reading)	241	188
Pasture day 45 (4th reading)	163	135

(*) De-Odorase, Alltech Inc. (Personal reference. Lyons Estate, University College, Dublin. l995).

In the case of a diet high in concentrate feed (Table 6), plasma urea nitrogen was significantly reduced with the addition of De-Odorase when a soybean meal was used as a protein supplement, although there was no effect when the nitrogen supplement was urea.

Whatever management alternative is used to control NUL/NUS levels, its negative effect is obvious when levels are not within those considered normal. The use of Yucca shidighera extract adds to the tools available to maintain NUL/NUS levels within the range considered normal.

Table 5. Effect of Yucca shidighera extract (*) and protein source on rumen and plasma nitrogen in steers fed high fibre diets.

	Nitrogen Source			
	Soybean Flour		Urea	
	Control	Y. shidighera	Control	Y. shidighera
Rumen pH	6,48	6,58	6,59	6,59
NH3 rumen, mg/dl	11,50	10,16	15,11	12,88
NH3 plasma, mg/mol	1,13	1,24	1,19	1,04
Plasma urea, mg/dl	13,64	14,79	16,11	14,66

(*) De-Odorase, Alltech Inc. KY. Source: Hussain and Cheeke (12).

Table 6. Effect of Yucca shidighera extract (*) and protein source on rumen and plasma nitrogen in steers fed a high concentrate diet.

	Soybean Flour		Urea	
	Control	De-Odorase	Control	De-Odorase
Rumen pH	5,81	5,82	6,09	6,00
NH3 rumen, mg/dl	7,92	6,88	10,85	10,50
NH3 plasma, mg/mol	1,17	0,89	1,15	1,15
Plasma urea, mg/dl	14,01	11,52	13,87	13,76

(*) De-Odorase, Alltech Inc. KY, U.S.A. Source: Hussain and Cheeke (12).

The recommended doses of commercial Yucca shidighera extract vary according to the NUL/NUS levels found. Doses of 3-4 g/animal/day are normal (with ULN between 12.6 mg/dL and 15.4 mg/dL) although higher ULN levels require 5-7 g/animal/day (with ULN between 15.4 mg/dL and 18 mg/dL) up to 8-10 g/animal/day (with ULN >18 mg/dL).

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