Original Research

Utilization of Milk Urea Concentration to Study Nitrogen Use Efficiency in Haouz Dairy Herds of Central Morocco

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Abstract

This study was conducted on ten commercial dairy herds, over one year to explore effects of feeding strategies on milk urea concentrations as a predictor of efficiency of nitrogen (N) utilization and urinary nitrogen excretion in dairy cows. Milk samples were collected monthly and analyzed for milk urea concentrations using a colorimetric procedure. Feed samples were characterized and their concentrations of protein digestible in the intestine and net energy for lactation were calculated according to the French system of PDI. Regression equations were performed to predict nitrogen in milk and urinary nitrogen excreting. Averages values were 28.3±2.1 mg.dl^{-1} for milk urea concentration, 26.8±5.1% for efficiency of N utilization and 178±16.2g/d for urinary nitrogen excreting. Significant correlation between urea in milk and crude protein content, milk production and urinary nitrogen excretion was observed (P<0.01). Negative association was found between efficiency of nitrogen utilization, milk urea content, urinary nitrogen excreting and milk production yield.

Key words: Crude Protein, Dairy Cows, Milk Urea Concentration, Nitrogen Utilization, Nitrogen Intake, Nitrogen Losses

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Introduction

Interest in the use of milk urea (MU) concentration as a practical indicator of dietary protein status in dairy cows has grown considerably in recent years. In ruminant species, excess protein is converted to ammonia in the rumen which is absorbed into the bloodstream and ultimately detoxified as urea by the liver. Nutritional factors that have major effects on MU concentration are amount of protein in the diets (Schepers and Meijer, 1998), rumen degradable protein and energy/protein ratio (Baker *et al*., 1995). Milk urea is highly associated (0.88 to 0.98) with blood urea and its level represents mainly (r = 0.86) N losses from rumen fermentation (Broderick and Clayton,1997). Lactating dairy cows eliminate 2.5 to 3% of the urea formed in liver through the milk (Melendez *et al*., 2000). The efficiency of nitrogen utilization in dairy cows is typically low and highly variable (10% to 40%) compared with the higher efficiency of other production animals (Calsamiglia *et al.*, 2010). In order to meet the nutritional requirements and sustain milk production, dairy producers often increase nutrients density of diets. However, the efficiency of feed protein is function of the amount of ammonia supply to the rumen and decreases as more crude protein is offered (Roy *et al.*, 2003). Although high dietary protein stimulates milk production, overfeeding of protein lead to an increase in urine urea excretion and has been found to be detrimental to reproductive and animal health (Guo *et al*., 2004).

In particularly, increasing the level of crude protein in diets increases the amount of nitrogen excreted in cow's urine and then decreases the efficiency of nitrogen utilization. Several studies have shown that excessive milk urea concentration could indicate the insufficient of use of degradable proteins by the micro-organisms present in the rumen, thus reflects excessive nitrogen losses to the environment (Faverdin and Vérité 1998; Godden *et al.*, 2001; Hof *et al.*, 1997). The objectives of this study were to examine the effects of diet composition and nitrogen intake on MU concentrations and assess the potential of MU concentrations as a predictor of urinary nitrogen excretion and the efficiency of N utilization under farm conditions.

Materials and Methods

Animals and Feeding Management

The study was undertaken on Friesian lactating cows from 10 dairy herds located within a semi-arid climatic region of Marrakech in the central part of Morocco, extending between latitudes 30° 50' and 32° 10' North and longitudes 7° 25' and 9° 25' West. During the experimental period, the animals were assigned into groups of 20 to 40 dairy cows. Forage components of diets consisted in corn silage (34.41%), fresh alfalfa (10.75%) and wheat straw (8.85%) completed by concentrate feeds: mixture concentrate feed (29.25%), soybean meal (3.90 %), wheat bran (6.42%) and meal corn (6.42%). Dairy cows were milked twice a day and individually fed after each milking at fixed hours. Farm grown Alfalfa green and wheat straw were offered to all the lactating cows at 08:00 and 14:00h. Maize silage, mixture concentrate feed, soybean meal and vitamin-mineral blend were offered as total mixed rations (TMR) into two equal parts and fed 2hours before each milking in morning(04:00h) and noon (16:00 h). The dairy cows were milked using a machine and had free access to water throughout the day.

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Diet Calculation, Sampling and Milk Urea Analysis

Investigative visits were made twice in every month on 10 commercial dairy farms from April 2017 up to march 2018. For each visit the milk sampling and information on composition of diets distributed to dairy cows were collected. Those diets were also characterized for organic matter, crude protein(CP) content , protein digestible in the intestine (PDI) with N or energy as limiting factor for rumen microbial growth (PDIN and PDIE) and net energy for lactation (UFL). The dry matter (DM) of forages was determined after drying the samples at 60°C for 48 hours. Diet calculation was based on information relative to feed composition and nutrient value of the feeds and animal requirements using French PDI system with respect to each farm visit. The requirements of the cows in terms of PDI and UFL were estimated following the INRA equations (Baumont *et al*., 2007). PDI and UFL balances were then estimated as the difference between allowances and dairy cow requirements, and protein balance in the rumen (OEB = *Onbestendige Eiwit Balans* in the Dutch system) was given by the difference between PDIN and PDIE of rations (Tamminga *et al*., 1994).

To determine the nitrogen intake (Ni), the crude protein (CP) content of the diet ingested was divided by 6.25 (Ni = CP/6.25). The regression equations: N milk (g/d) = 188 - 0.25*CP; NUE (g/d) = -32+16. 1*MUN were developed to predict respectively N in milk and N urinary excreting (NRC, 2001; Roy *et al*., 2003). The equation (ENU = g N milk /g Ni) was used to estimate efficiency of N utilization (Huhtanen and Hristov 2009; Calsamiglia *et al*., 2010). For individual cows, the information on test day milk production, milk fat and protein content, body weight, parity and stage of lactation were collected from farm records. Daily milk productions were adjusted for an identical period of days in lactation in order to compare the milk productions between dairy herds. The milk yield was calculated based on lactation cycle of 305 days. Milk samples were analyzed for urea content using a colorimetric p-dimethyl-amino-benzaldehyde (4-DMAB) procedure descripted by Dhali *et al*. (2005) after little modification. The milk urea content was measured at 420 nm and expressed in milligram per deciliter (mg/dl) of milk.

Statistical Analysis

Numerical data was analyzed statistically using the Statistical Package for the Social Sciences (SPSS, 2011). To determine whether effects were significant in explaining variations in MU concentrations, crude protein (CP) of diet, nitrogen intake (Ni), daily milk production (DMP), efficiency of nitrogen use (ENU) and urinary nitrogen excretion (UNE) the data were analyzed using GLM procedure(SPSS,2011). The diet crude protein, nitrogen intake, daily milk production, yield milk were taken as sources of variations. The Pearson correlation analysis was performed to investigate the association between different traits. Significant differences were analyzed using the ANOVA test and statistical significance was declared at $P<0.05$.

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Results and Discussion

Effect of CP Content of Diet on MU Concentrations, DMP, ENU and UNE

The results on MU concentrations, CP content, DMP, ENU and UNE are presented in Table1. Diets composition have mean values of 24.5 ± 2.6 kg for DM, 152±15.8 for CP content (g/kg DM), 22.6±2.7 for UFL, and 584±106 g/d for Ni and -207±111g/d for OEB. The offered diets in participating farms were characterized by deficit in rumen degradable protein balance (negative OEB) which signify that the diets had high proportion of rumen degraded protein (RDP) compared to none degraded protein in the rumen of feed ingredients. A negative value of OEB might also indicated inadequate of N intake in lactating cows and therefore, the microbial activity as well as the synthesis of microbial proteins may be impaired (Tamminga *et al.*, 1994).

During investigation, the mean of MU concentration was 28.3±2.1 mg/dl. Statistical analysis (ANOVA), did not found a significant variation between MU concentrations in milk samples. This observation may reflects little variation in the quality of the protein fed to the dairy cows. The correlation coefficients presented in Table 2 reveals that milk urea concentration increased linearly as CP and N intake increased in the feed. It is noted that high urea in milk indicates that excess protein has been fed to the dairy cow (Jonker *et al.*, 2002) and there high nitrogen losses to environment (Calsamiglia *et al.*, 2010). In participating dairy farms, the ENU of cows averaged 26.8±5.1%. A recent study reported that ENU of dairy cows in North America, averages 26.1% of Ni; the corresponding percentages for dairy cows in Northern Europe is 27.4% (Patton *et al.*, 2014). These regional differences might be explained in part by the difference in N intake. For other study, from 20 to 35% of ingested nitrogen is excreted as protein in milk and over than 50% of consumed nitrogen is found in the urine (Tamminga *et al.*, 1994). This study showed that the conversion of N into milk protein (which explain level of ENU) of dairy cow Holstein in semi-arid conditions of central Morocco is low. This low ENU has implications not only for production performance and profitability, but also for the emission of contaminants to the environment.

In particularly, the findings of this study showed that dairy cow Holstein excretes N (178 ± 16.2g /d) in urea and it secretes N (150±3.9g/d) as milk protein. Recent study conducted in North America reported that the lactating dairy cow excretes as much urinary urea-N (168 g/d) than it secretes N (166 g/d) as milk protein (Wattiaux and Ranathunga, 2015).

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Table 1: Descriptive analysis of the variables studied

Item	Means	SE	Min	Max
BW, kg	636	49	532	713
DM intake, kg/d	24.3	2.6	19.9	28.7
CP of diet, g/d	152	15.8	132	180
CP concentrate mixture, g/d	184	15.7	170	220
N intake, g/d	584	106	419	741
PDI Balance				
PDI requirements, g/d	1607	151	1326	1910
PDIN allowances, g/d	2296	428	1706	2985
PDIN balance, g/d	674	319	196	1075
OEB, g/d	-207	111	-325	-68
Aptitude of Production				
DMP, kg/d	20.2	2	18	25
Milk yield, kg	6185	598	5551	7625
N milk, g/d	150	3.9	143	155
MU concentrations, mg/dl	28.3	2.1	25	32
ENU, %	26.8	5.1	19.3	36.7
UNE, g/d	178	16.2	153	202

SE: Standard Error; DM: dry matter intake; MU: milk urea; PDI: protein digestible in the intestine; PDIN: protein digestible in the intestine with nitrogen as limiting factor for rumen microbial growth; OEB (Onbestendige Eiwit Balans): rumen protein degradable balance; CP: crude protein; DMP: daily milk production; ENU: efficiency of nitrogen utilization; UNE: urinary of nitrogen excretion.

Generally, increasing the percentage of dietary CP increases N intake and urinary urea-N excretion and decreases ENU. Through an extensive literature survey(Wattiaux *et al*., 2005), the commonly accepted "optimal" MU concentrations of 21.7 to 25.7 mg/dl which reflects high ENU but the milk protein production can be at maximum for any MU concentrations values ranging from 21.7 to 34.7 mg/dl(Nousiainen *et al*., 2004; Wattiaux and Ranathunga, 2015).

Relationship of Milk Urea Concentrations, CP Content of Diets, Milk Production, ENU and UNE

The findings on associations among MU concentrations, CP content of diets, milk production, ENU and UNE are presented in Table 2. During investigation, MU concentrations was found to be significantly associated with CP content of diet (P<0.00). A study also reported marginally closer relationships between MU concentrations and dietary CP content (Broderick and Clayton, 1997). A close positive correlation was found between MU concentration (P<0.05) and CP content of mixture concentrate in agreement with the results obtained by Dhali *et al.* (2005). A negative correlation was found (p<0.05) between MU concentrations and ENU in agreement with the results obtained by several authors (Nousiainen *et al.*, 2004; Jonker *et al*., 1998). Then again, CP content of mixture concentrate was found to affect negatively the ENU in dairy farms and increased significantly the nitrogen losses in environment. The results Table 2 reveals that UNE was significantly increased when the CP content of diet was high and the ENU tended to decrease when the MU concentrations increased. Ciszuk and Gebregziabher (1994) confirmed the same observation.

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It is noted that increase CP mixture concentrate in diets based in lower CP forage lead to reducing in converting of N dietary to milk protein (Clark *et al*., 1992) and increase the N excretion in urine and milk (Jonker and Kohn, 2002). Subsequently, reduction in dietary CP of 18% to 16.2% (dietary dry matter basis) allows to reduce urinary urea-N from 178 g/d to 134 g/d which could represented 24.7% of reduction (Wattiaux and Ranathunga, 2015).

Table 2: Relationship of milk urea concentration and others factors affecting efficiency of nitrogen utilization in 10 modern dairy farms

Particulars	**Correlation Coefficient (r)**	
	MU Concentration	**ENU,%**
Number of cows	0.761*	-0.703*
CP content of diet, g/d	0.738**	-0.646*
CP of concentrate mixture, g/d	0.775**	-0.626
N intake, g/d	0.791**	-0.821**
DMP, kg/d	0.538	-0.63
Milk yield, kg	0.765**	-0.825**
N milk, g/d	0.901	0.252
ENU, %	-0.669*	1
UNE, g/d	0.988**	-0.692*
MU concentrations	1	-.0669*

**Indicates the r value is significant at p<0.05; ** Indicates the r value is significant at p<0.01.*

Coefficients of correlation between factors showed in Table 2 confirm that amount of N intake has an effect on MU concentrations, which is evidence of that overfeeding proteins contribute to reduce the ENU of dairy cow and to increase N excretion in urine. Therefore, commercial dairy farmers may find it advantageous to monitor MU concentrations, which could help to improve efficiency of nitrogen utilization and decreases N losses in dairy farms.

Conclusion

The urea concentration of cow's milk can be utilized for a finer tuning of protein feeding, in order to improve milk N efficiency and reduce urinary N excretion. The main factor influencing MU concentrations is the amount of crude protein content in diet offered to dairy cows. The impacts of changing strategies of feeding on commercial dairy farms to improve the efficiency of nitrogen use and reducing N excretion could be monitored through changes in milk urea concentrations.

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