Small Ruminant Research 121 (2014) 96–100

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Relationship between milk urea level, protein feeding and urinary nitrogen excretion in high producing dairy goats☆

L. Rapetti*, S. Colombini, G. Galassi, G.M. Crovetto, L. Malagutti.

Department of Agricultural and Environmental Sciences – Production, Landscape, Agroenergy, University of Milan, Via Celoria, 2, 20133 Milan, Italy

ARTICLE INFO

Article history:
Available online 21 April 2014

Keywords:
Milk urea
Dairy goat
Protein feeding
Urinary nitrogen excretion

ABSTRACT

The aim of this study was to evaluate in high producing dairy goats the relationship between milk urea level (MUL) and diet composition, milk yield (MY), intestinal digestible protein (PDI) balance, milk N efficiency and urinary N (UN) excretion. Twenty-one mean treatment data, derived from thirteen diets tested in five experiments conducted on goats kept in metabolic cages to collect separately feces and urine, were used. Diets, orts and milk were analyzed for chemical composition; urine was analyzed for N content. PDI with N as limiting factor for rumen microbial growth (PDIN) was calculated according to the French system as well as PDI requirements. Relationships were developed using regression analysis based on mixed models that account for between-experiment variation. There were significant relationships between MUL (mg/dL) and dietary crude protein (CP) (g/kg DM): MUL = –45.3 + 0.484 CP (R^2 = 0.914), and between MUL and PDIN balance (%): MUL = 22.9 + 0.347 PDIN balance (R^2 = 0.917). The relationship between MUL and MY was not significant. Milk N efficiency resulted negatively related with MUL and positively related with MY (kg/d): milk N efficiency = 33.8–0.38 MUL + 2.58 MY (R^2 = 0.869). UN excretion (g/d) was positively related with MUL: UN excretion (g/d) = 14.4 + 0.348 MUL (R^2 = 0.713).

The urea concentration of goat's milk can be utilized for a finer tuning of protein feeding, in order to improve milk N efficiency and reduce urinary N excretion.

1. Introduction

Urea, the main form of excretory nitrogen (N) in mammals, derives from the detoxifying conversion in the liver of the ammonia (NH_3) circulating in the blood. This NH_3 mainly originates from excess of degraded N in the rumen, from excess of true protein digested in the small intestine, and from amino acids catabolized in gluconeogenesis (Schepers and Meijer, 1998). Although the majority of urea is excreted in the urine, from the liver urea easily diffuses into plasma and milk, explaining the close relationship between milk urea level (MUL) and blood urea concentration (Broderick and Clayton, 1997) and urinary N (UN) excretion (Kauffman and St-Pierre, 2001; Nousiainen et al., 2004). For these reasons, MUL is used in dairy cows as a diagnostic of protein feeding adequacy and to predict UN excretion (Nousiainen et al., 2004). For dairy cows, Jonker et al. (1998) calculated MUL target values in the range between 21 and 34 mg/dL, depending on milk production. For dairy goats, Brun-Bellut et al. (1991) reported an optimum MUL range of 28–32 mg/dL, but less knowledge is available for this species, especially for high producing dairy goats. The high MUL values (40 mg/dL, on average) of bulk milk samples found in dairy goat farms in Northern Italy (Rapetti et al., 2009a) can be ascribed, at least in part,

☆ This paper is part of the special issue entitled Industrial and Rural Activities in the Goat Sector including Science, Innovation and Development (Based on XIth International Conference on Goats, Gran Canaria, Spain), Guest Edited by Noemí Castro.

* Corresponding author. Tel.: +39 02 50316436; fax: +39 02 50316434
E-mail address: luca.rapetti@unimi.it (L. Rapetti).

http://dx.doi.org/10.1016/j.smallrumres.2014.04.006
0921-4488/

Table 1
Description of diet composition, dry matter intake, milk production, urinary nitrogen excretion and intestinal digestible protein and energy balance data ($n = 21$) used for evaluation.

	Mean	SD	Min	Max
Days in milk, d	81	60	12	221
Body weight, kg	57.8	4.88	43.6	66.0
Diet composition				
Organic matter, g/kg DM	912	23.0	868	944
CP, g/kg DM	163	26.4	129	214
Ether extract, g/kg DM	40	15.1	18	59
aNDFom, g/kg DM	338	30.8	302	399
ADFom, g/kg DM	218	33.6	178	277
Lignin (sa), g/kg DM	44	24.8	21	96
NFC,[a] g/kg DM	392	54.4	288	476
PDIN,[b] g/kg DM	115	20.7	90	157
PDIE,[c] g/kg DM	112	18.8	92	153
UFL,[d] n/kg DM	0.940	0.058	0.821	1.000
DM intake and milk production				
Dry matter intake, kg/d	2.44	0.34	1.98	3.05
Milk yield, kg/d	3.95	0.86	1.84	5.49
FPCM,[e] kg/d	3.82	0.88	2.20	5.68
Fat, %	3.50	0.74	2.34	4.87
Crude protein, %	3.20	0.34	2.68	3.78
True protein, %	2.84	0.32	2.43	3.41
Lactose, %	4.61	0.31	3.95	5.11
Milk urea level, mg/dL	34.2	14.5	11.9	67.5
Milk N efficiency,[f] %	31.0	7.8	14.7	44.4
Urinary nitrogen excretion				
Urinary nitrogen, g/d	17.4	7.81	8.5	38.6
PDI balance				
PDI requirements, g/d	215	39	145	313
PDIN allowances, g/d	281	72	209	458
PDIN balance, g/d	66	80	−48	266
PDIN balance, %	34.5	43.0	−18.8	139.4
UFL balance				
UFL requirements, n/d	2.48	0.38	1.82	3.27
UFL allowances, n/d	2.29	0.32	1.78	2.97
UFL balance, n/d	−0.19	0.29	−0.88	0.22
UFL balance, %	−7.03	10.4	−30.5	9.2

[a] NFC: non-fiber carbohydrates = 100 − (ash + crude protein + ether extract + aNDFom).
[b] PDIN: protein digestible in the intestine, with nitrogen as limiting factor for rumen microbial growth.
[c] PDIE: protein digestible in the intestine, with energy as limiting factor for rumen microbial growth.
[d] UFL: forage unit for milk production (1 UFL = 7.1128 MJ of net energy for lactation).
[e] FPCM: fat (35 g/kg) and protein (31 g/kg) corrected milk = milk yield (kg/d) × (0.263 + 0.1375 × milk fat (%) + 0.0825 milk true protein (%)). This equation is derived from Eq. (7.3) reported by Sauvant et al. (2007).
[f] Milk nitrogen efficiency = milk N/N intake × 100.

to the lack of information and of consciousness regarding this matter.

Furthermore, for dairy goats, only few studies (Ciszuk and Gebregziabher, 1994; Decandia et al., 2011) investigated the relationship between MUL and nitrogen excretion. Moreover, to our knowledge, regression analyses based on mixed model that takes into account the effect of the experiment were never developed.

The aim of this study was to evaluate in lactating goats the relationship of MUL with: (1) diet composition, milk production and PDI balance, (2) milk N efficiency, and (3) urinary N excretion.

2. Materials and methods

2.1. Dataset

Twenty-one mean treatment data were derived from five experiments (Bava et al., 2001; Rapetti and Bava, 2004; Rapetti et al., 2005, 2009b; Colombini et al., 2010) in which thirteen different dietary treatments were tested. In three experiments (Bava et al., 2001; Rapetti et al., 2009b; Colombini et al., 2010) the dietary treatments were evaluated in different stages of lactation, therefore, in these cases, we considered as mean treatment data each dietary treatment for each stage of lactation.

The trials, conducted at the experimental center of the Department of Agricultural and Environmental Sciences of University of Milan, were performed using the same measurement methods, laboratory equipment and technicians. The experiments were conducted on lactating Saanen goats ($n = 42$) kept in individual metabolic cages for total separate collection of feces and urine.

Feeds, orts, milk and urine were daily measured and sampled during the seven days of each experimental period. Diets were characterized for organic matter, crude protein (CP), ether extract, neutral detergent fiber (aNDFom), acid detergent fiber (ADFom), lignin (sa), non-fiber carbohydrates (NFC), PDI with N or Energy as limiting factor for rumen microbial growth (PDIN and PDIE) and net energy for lactation reported as forage unit for milk production (UFL). Concentrations of PDIN, PDIE and UFL were calculated using the equations reported by Baumont et al. (2007). In addition to diet composition, animal measures such as days in milk (DIM), body weight (BW), dry matter intake (DMI), MY, fat and protein corrected milk (FPCM), milk crude protein, milk true protein, lactose, MUL and UN were considered. Particularly, MUL was determined using the pH-differential technique (ISO 14637, 2006). The requirements of the goats in terms of PDI and UFL were estimated following the equations of Sauvant et al. (2007). PDI and energy balances were then estimated as the difference between allowances and requirements.