Effect of genotype and lactation on milk urea nitrogen, blood urea nitrogen and milk composition of dairy cows

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Abstract

This study was aimed to evaluate milk urea nitrogen (MUN) of cows considering variations in dietary nutrition, genetic quality and lactation yield which will be helpful to develop practical feeding guidelines for dairy cows based on MUN. A total of forty dairy cows consisting 20 native and 20 crossbred milking cows were selected in Sonaimuri, Noakhali in winter season to know the daily feed availability to cows. Feed, milk and blood samples were collected and analyzed. The dry matter intake of the local and crossbred cows were 2.58 and 2.74 (g/100 kg live weight respectively) and they did not show statistical variation ($p<0.05$). Metabolizable energy (ME) and protein intake showed significantly higher values in crossbred (85 MJ/day and 815 g/day) compared to local (40 MJ/day and 395 g/day) cows in winter season ($p>0.05$). Live weight, body condition score and milk yield and MUN varied significantly between genotypes although blood urea nitrogen (BUN) value did not differ significantly. Strong correlation between lactose and protein percentage was observed in both the lactations in local cows. Milk minerals are negatively correlated with protein, SnF and minerals in first lactation whereas moderate to strong relation was observed in second lactation with those parameters. Milk constituents didn’t show any difference between local & crossbred cows. Strong correlation between milk protein and lactose with SnF were observed in both local and crossbred cows in first lactation stage. BUN value showed a moderate correlation between milk yields of local cows. The results revealed that genotype and lactation have no effect on BUN although MUN value showed significant difference between local and crossbred cows.

Key words: genotype, lactation, dairy cow, milk urea nitrogen, blood urea nitrogen

Introduction

Dairy cows of the different production systems are maintained at variable nutritional planes, which depend on the genotype, seasons, cropping pattern and availability of backward linkage supports. Monitoring nutritional plane of dairy cows is essential, and is not done due mainly to knowledge gaps, and unavailability of easy tools to assay the complex nutritional process of dairy cows. The milk collected under the structured cooperative milk marketing system is priced according to its fat content, value addition to milk as yield several milk products, but still the milk fat has limitations to establish it as a tool to identify the plane of nutrition of the cows.

Milk, one of the physiological products of cows, varies in composition depending on plane of nutrition of cows, any relation between the composition of milk and the diets fed to cows may produce some options to develop feeding guides for milking cows. Feeding too much dietary protein, and diets containing higher level of degradable and/or soluble protein such as urea may raise milk urea nitrogen (MUN), even a diet contains a normal level of total crude protein (CP). Variation in lactation yield and genetic quality of cows fed diets containing similar level of nutrition, especially of protein, may also affect MUN contents. Evaluation of MUN content during collection time of milk may give a good indication on the protein availability of cows from the plane of nutrition that varies on seasons and cropping systems.

MUN, a fraction of milk protein that is derived from Blood Urea Nitrogen (BUN), may be a useful tool that may help to monitor any change required in the feeding and management of a dairy herd. This MUN indicator may guide farmers for better feeding of their cows to increase productivity, and to bring more economic benefits and nutrition for their family. Average MUN values may range from 100 to 140 mg/L (Carlsson and Pehrson, 1994; Moore and Verga, 1996). The liver converts ammonia to urea to be excreted or recycled and it diffuses freely across the cell membranes into blood and, therefore, MUN concentrations represent BUN. If BUN values are elevated, the MUN will be elevated. If MUN values are high, a herd may experience wasting of feed protein along with excess excretion of nitrogen into the environment causing pollution. If MUN values are too low, the rumen microbial protein yield may be reduced thereby limiting milk production and milk protein yield (Brodrick and Clayton, 1997).

Feeding standard, ration formulation, software use etc are the tools for feeding according to requirement of the animal, but their use by the farmers, especially in developing countries is absent. Determination of milk protein and MUN may, in one hand, be used as an indicator if milk quality and, on the other hand, as a guiding tool for feeding dairy cows. Determination of MUN values may save feed cost, and improve production. This study was undertaken to determine the existing status of MUN of cows considering variations in dietary nutrition, genetic quality and lactation yield of cows at Sonaimuri, Noakhali.

Materials and Methods

Cow and site selection

Forty cows were selected consisting of 20 native (local cow) and 20 crossbred (Local × Holstein-Friesian) origins (genetic quality) with 10 cows in each lactations (lactation 1 and lactation 2) for each genotypes in Sonaimuri (Noakhali, Bangladesh), in winter season (dry).

Feedstuffs and their chemical composition

The data on feeds and feeding systems of two genotypes (local and cross) of cows were collected through a survey schedule. The daily feed intake of the selected cows were recorded for seven days then these were made average and composite samples were analyzed for nutrient composition using methods described by AOAC (2004) to determine the plane of nutrition (Table 1).

Table 1. Chemical composition of available feed stuffs

Ingredient	DM %	Ash %	ADF %	CP %	EE %	ME (MJ/kg DM)
Rice straw	90.34	14.66	44.01	3.88	0.53	6.00
Bucksa grass	50.49	12.42	-	9.51	1.09	-
Water hyacinth	8.61	1.53	-	18.10	0.94	-
Durba	45.36	42.95	-	8.09	0.39	-
Dhal	6.13	2.40	-	14.53	0.78	2.50
Rice polish	89.33	12.80	38.24	8.86	6.04	14.14
Wheat bran	87.49	4.43	10.42	15.23	4.23	10.50
Sesame cake	93.26	13.80	27.01	31.08	8.72	13.89
M. Cake	90.89	14.64	29.61	32.74	9.10	12.67
Molasses	86.24	13.96	-	5.10	-	14.98

Determination of milk composition

Daily milk yield was recorded and samples of morning and afternoon milk were collected and analyzed for fat, protein, lactose, SnF and minerals in Dairy Science Lab. of Animal Production Research Division (APRD), BLRI using a Milk Analyzer (LactoStar, Funke Gerber, Berlin, Germany)).

Determination of BUN and MUN

Blood samples were collected directly from the jugular vein and serum was separated. Milk and blood serum were analyzed following a newly developed HPLC based method of APRD Lab. (Knauer, Berlin, Germany) for MUN and BUN content. HPLC- binary gradient or isocratic system consisting a HPLC-Pump K-501 solvent delivery system, a manual injector, a K-2501 spectrophotometric UV detector all from Knauer, a 250mm × 4mm NH_2 column, 95% acetonitrile in de-ionized water @ 1.0 ml/min was the mobile phase and detection was done at 195 nm. Only for BUN values, the results were cross checked with an analytical kit.

0, 0.5, 1.0, 2.0, 4.0, 6.0, & 10.0mg/dl urea standard solution was prepared in acetonitrile. The concentration of MUN and BUN was calculated from the standard curve. 500 μl milk sample & 500 μl metaphosphoric acid solution (1.12%) was taken in a eppendrof tube, the mixture was vortexed & centrifuged at 3000 rpm at 4°C for 20 min to precipitate protein. 100 μl supernatant was taken to another eppendrof tube and 900 μl acetonitrile was added, mixed well & centrifuged at 1000 rpm at 4°C for 10 min to precipitate. Supernatant was filtered with syringe filter & 80 μl supernatant was injected.

Animal weighing and BCS

Live weight of each cow was measured using a calibrated electronic digital scale (Portable Digital Cattle Weighing Balance, developed by APRD Lab., BLRI) and Body Condition Score (BCS) was assessed by palpating individual body parts, and an average score was recorded on a 5-point scale, where 1 was emaciated and 5 was obese (Wildman, *et al.*, 1982).

Computation and statistical analysis

Requirements and intakes of energy and protein of cows were calculated according to Kearl (1982). Digestible protein of feed was calculated from the analyzed composition and energy of feed was according to Kearl (1982) and Singh and Oosting (1993). Statistical analysis of data was done through SAS software to determine the treatment effects on MUN and relations with the quality of diets and milk.

Results and Discussion

Effect of existing feed base, genotype and lactation on live weight, body condition score (BCS) and feed intake are shown in Table 2. The live weight and BCS of cow under existing feed resource base were (205 kg and 2.03 for local and 419 kg and 3.27 respectively) significantly ($P<0.05$) different in winter season. Average daily dry matter intakes (DMI) per 100 kg live weight for local and crossbred cow were 2.58 and 2.74 respectively which did not show statistical difference in the existing management practice (Table 2). Daily ME intake per cow at Sonaimuri were 40 MJ for local and 85 MJ for crossbred cow which differed significantly ($P<0.05$). Daily dietary protein intake 395g and 815g for local and crossbred cow differed significantly. Energy/protein ratios in local (0.100) and crossbred cows (0.104) were almost similar that was noticed in the study. The roughage/concentrate ratio was significantly higher in local (2.86) and crossbred cows (3.66) in their existing management condition ($P<0.05$). Intake of roughage and concentrate individually by both genotypes (local 3.92 and 1.40 kg DM; crossbred 8.89 and 2.43 kg DM) showed significant difference between the genotypes.

Table 2. Effect of genotype (local and crossbred cow) on live weight, body condition score and feed intake of dairy cows

Parameters	Mean value		Significance
	Local cow	Crossbred cow	
Live weight (kg)	204.69 ^{b} ±5.07	418.82 ^{a} ±18.38	**
Lactation 1	205.12 ^{b} ±5.92	421.43 ^{a} ±31.39	**
Lactation 2	204.27 ^{b} ±8.58	416.21 ^{a} ±20.98	**
BCS	2.03 ^{b} ±0.08	3.27 ^{a} ±0.08	**
Lactation 1	2.03 ^{b} ±0.12	3.20 ^{a} ±0.13	**
Lactation 2	2.05 ^{b} ±0.14	3.35 ^{a} ±0.11	**
DMI (kg)/100kg live weight	2.58±0.12	2.74±0.02	NS
Roughage (kg DM)	3.92^{b} ±0.31	8.89^{a} ±0.65	**
Concentrate (kg DM)	1.40^{b} ±0.09	2.43^{a} ±0.23	*
Roughage : Concentrate	2.86^{b} ±0.19	3.66^{a} ±0.17	*
Protein intake g/day	395.25±4.76	814.75 ^{a} ±7.36	**
ME (MJ/ day)	39.55 ^{b}±1.37	85.35 ^{a} ±2.06	*

**, P<0.01, *, P<0.05 level, NS, Not significant

Crude protein concentrations had a significant effect on milk, milk fat, and protein production, plasma urea N, MUN, and on N balance measurements (Kauffman and St-Pierre, 2001) but crude protein levels had a low effect on milk yield and composition (Zhai et al., 2006). The main factor influencing these concentrations is not the amount of protein ingested as per requirement, but the relationship between protein and fermentable carbohydrate in ration (Oltner and Wiktorsson, 1983; Roseler et al., 1993; Lykos et al., 1997). With adequate dietary energy, MUN indicates protein status. MUN concentration increased when different forms of protein were fed in excess of National Research Council recommendations with no difference in milk production (Roseler et al., 1997).

A decreasing trend in weight loss was observed in lactation 1 and 2 (≤ 100 DIM and ≥ 100 DIM) in both the genotypes was observed (Table 2). There was a moderate correlation among body weight and body condition score observed in both genotypes (R^2 of local cow 0.79 and crossbred cow 0.87). These relationships are shown in Fig. 1 for local cows and Fig. 2 for crossbred cows.

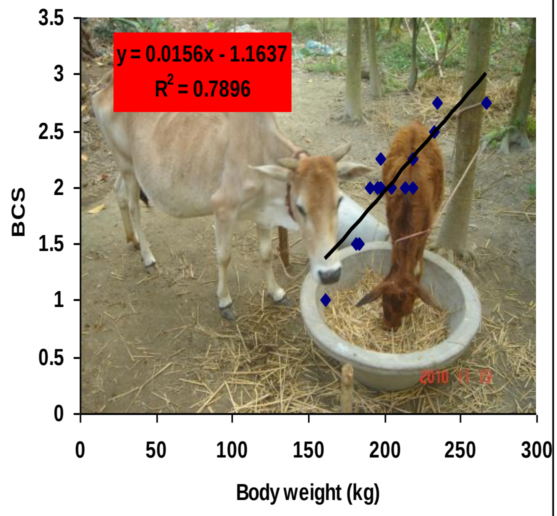

Fig 1. Relationship between BCS and body weight of local dairy cows

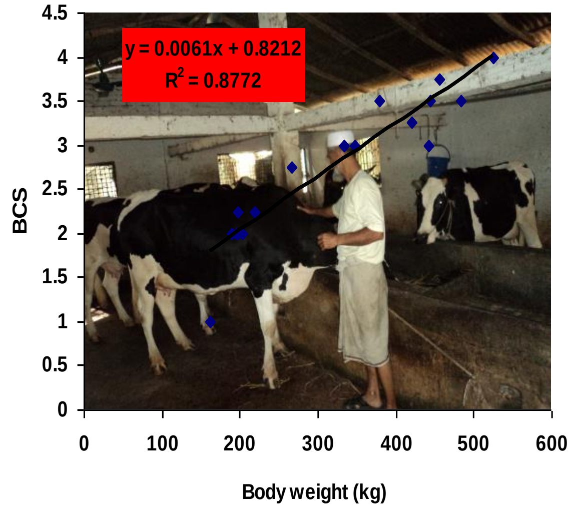

Fig 2. Relationship between BCS and Body weight of crossbred dairy cows

In Table 3, milk yield (1.28 kg/day/cow for local and 7.62 kg/day/cow for crossbred cow) differed between the genotypes significantly while milk constituents (fat, protein, lactose and SnF) did not vary (P<0.05). Feed base affected significantly the percentage of mineral (0.65% & 0.74%) in our current study which supported previous study done by Baset et al. (2009).

Table 3. Effect of genotype (local and crossbred cow) on milk yield, milk composition blood urea nitrogen and milk urea nitrogen of dairy cows

Parameters	Mean value		Significance
	Local cow	Crossbred cow	
Milk yield (kg)	1.28^{b} $\pm 0.16^{b}$	7.62^{a} ± 1.02	**
Fat (%)	3.86±0.23	3.86±0.22	NS
Protein (%)	3.77±0.13	3.81±0.05	NS
Lactose (%)	5.48±0.19	5.52±0.17	NS
SnF (%)	10.06±0.35	10.14±0.14	NS
Mineral (%)	0.65^{b} ± 0.02	0.74^{a} ± 0.01	*
MUN (mg/dl)	26.75^{b} ± 1.95	29.46^{a} ± 1.66	*
BUN (mg/dl)	23.85±1.95	22.50±1.66	NS

**, P<0.01, *, P<0.05 level, NS, Not significant

The blood urea nitrogen (BUN) values of local and crossbred cow were not statistically different (Fig. 3) whereas MUN values were affected significantly by the genotypes (26.75 mg/dl for local and 29.46 mg/dl for the crossbred cow) which are shown in Fig. 4.

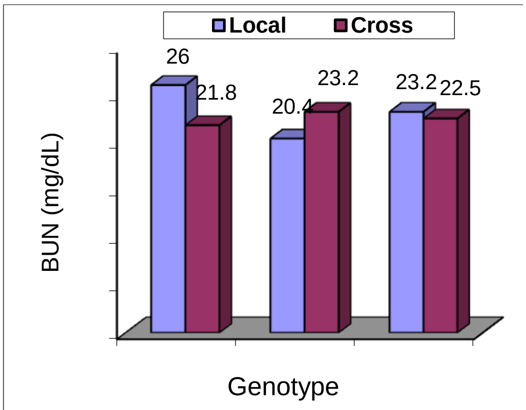

Fig. 3. Effect of genotype and lactation on the BUN value of cows

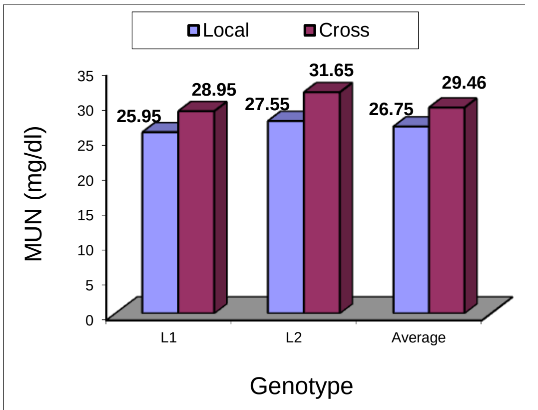

Fig 4. Effect of genotype and lactation on the MUN value of cow

The correlations among the milk compositions are shown below. In Table 4-5, strong correlation between lactose and protein percentage was observed in both the lactations in local cows. Milk minerals are negatively correlated with protein, SnF and minerals in first lactation where as moderate to strong relation was observed in second lactation with those parameters. Milk constituents didn't show any difference between local and crossbred cows.

Table 4. Correlation between milk components with milk yield of local cows in first lactation

	Fat%	Protein%	Lactose%	SnF%	Minerals%	BUN (mg/dL)	Milk yield
Fat%	1						
Protein%	0.43	1					
Lactose%	0.37	0.99	1				
SnF%	0.40	0.99	0.99	1			
Minerals%	-0.12	-0.08	-0.07	-0.08	1		
BUN mg/dL	-0.16	-0.56	-0.56	-0.56	-0.61	1	
Milk Yield	-0.35	-0.18	-0.17	-0.17	-0.19	0.06	1
MUN g/dL	0.67	0.47	0.44	0.46	-0.25	-0.42	0.07

Table 5. Correlation between milk components with milk yield of crossbred cows in first lactation

	Fat%	Protein%	Lactose%	SnF%	Minerals%	BUN mg/dL	Milk yield
Fat%	1						
Protein%	0.43	1					
Lactose%	0.38	0.99	1				
SnF%	0.39	0.99	0.99	1			
Minerals%	-0.13	-0.09	-0.07	-0.08	1		
BUN mg/dL	-0.16	-0.56	-0.57	-0.56	-0.62	1	
Milk Yield	-0.35	-0.19	-0.17	-0.17	-0.19	0.06	1
MUNmg/dL	0.67	0.48	0.45	0.46	-0.26	-0.42	0.08

Some studies reported that MUN concentration were lower at first lactation than in older cows (Godden et al. 2000; Oltner et al. 1985), others have found no such relationship (Canfield et al. 1990). Several studies reported that urea levels vary considerably by stage of lactation (Bruckental et al. 1989; Carlsson et al. 1995). Carlsson et al. (1995) reported that MUN concentrations were lowest immediately after calving, increased to reach a maximum between 3 and 6 month of lactation, and then slowly declined in later lactation. This suggests that the association between stage of lactation and urea concentration is explained by underlying nutritional management (Schepers and Meijer, 1998). Urea concentration in milk and plasma are closely related (Gustafsson and Plamquist, 1993). Several investigators have suggested the possibility of using either of them as a supplementary indicator of nitrogen utilization and feeding adequacy in dairy cows (Roseler et al. 1993; Baker et al. 1995; Hof et al. 1997; Shepers and Meijer, 1998; Jonker et al. 2002; Dhali et al. 2005). Milk urea nitrogen (MUN) provides an accurate reflection of how much nitrogen is absorbed by the cow, but not used for growth or milk protein synthesis. Most of these nitrogens are absorbed by feed. MUN assay may be a useful tool to tell us when a cow remains deficit in protein supply or wastes feed protein. Dhali et al. (2005) worked on the effect of urea supplemented and urea treated straw based diet on milk urea concentration in crossbred. A number of investigations were done and many authors reported that MUN is a dietary monitor for dairy cows (Garcia et al. 1997; Gustafsson et al. 1993; Oltner et al. 1983, 1985)

Conclusions

It may be concluded that genotype and lactation have no effect on blood urea nitrogen value while milk urea nitrogen showed significant difference with local and crossbred cows

Acknowledgement

The authors are grateful to Bangladesh Agricultural Research Council (BARC) for financial support under SPRG, NATP Phase-1 project to conduct the above studies. The authors also acknowledge the assistance provided by the staffs of the laboratory.

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