RELATION BETWEEN MILK PROTEIN AND UREA CONTENT IN DIFFERENT FARMS

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Abstract

Milk production and milk composition are of prime economic importance for farmers. It is well known in dairy management that the balanced feeding and holding technology is an important lever by which milk production and milk composition can be modified. The objectives of this work are to establish relation among milk protein and urea content in different farms. Four farms represent three cow breeds (Holstein Black and White, Latvian Brown, and cross breed XP). Individual cow milk samples (n=8400) were collected monthly from September 2009 to November 2010. Milk samples were analyzed for total protein, casein, fat, lactose, and urea content with instrumental infrared spectroscopy method. The average milk yield in farms was significantly different (from 26.8 to 16.0 kg per control day), and average protein content varied from 3.32 g kg^{-1} to 3.62 g kg^{-1}. The urea content in cow milk was between 21.3 to 42.6 mg 100 mL^{-1}. The average protein content was higher and significantly ($p<0.05$) different in first yield level (up to 15 kg) for all farms. Overall, in different farm and milk yield levels correlation between protein and urea was low or very low. In the farm C, average urea content ranged between 30.0 and 60.0 mg 100 mL^{-1}, which indicated problems in feeding or management in the farm. It was established that milk productivity traits significantly ($p<0.05$) varied in farms with different dairy cow holding and feeding technologies and milk protein and urea content significantly ($p<0.05$) varied for cows with different milk yield per day.

Key words: dairy cow, milk yield, protein and urea content.

Introduction

Milk is a complex biological fluid consisting of fats, proteins, minerals, vitamins, enzymes, and lactose. The composition of milk varies according to the breed, the genetic background of the animal, the stage of lactation, the nutritional quality of the animal's feed, the milking technology, and the incidence of disease such as mastitis and general environmental conditions (Coballero et al., 2003; Savickis et al., 2010).

The most important milk components for cheese and curd production are milk proteins. Now in Latvia the milk payment system is based on the content of total protein in milk, and on milk amount. Therefore task of the Latvian breeding programmes will be high milk yields with high protein content.

Normal bovine milk contains 30 to 35 g of protein kg^{-1}. Milk total proteins are composed of casein, whey proteins, and non-protein nitrogen (Depeters and Cant, 1992). The two principal types of milk proteins are caseins and whey proteins. Caseins constitute 76 to 86% of the total milk protein. Whey proteins represent 14 to 24% of milk proteins and are in solution in the serum phase of milk (Hui, 1993).

Researchers (Joudu et al., 2008) have found that the content of proteins and caseins in different breed's cow milk is different. Observe that Estonian Red breeds cow milk content highest protein and casein that Estonian Holstein breeds cow milk. On the contrary S.M. Carroll et al. (2006) did not find affect from Holstein, Jersy, and Brown Swiss cows breed or diet in milk total nitrogen and urea nitrogen content.

Urea is therefore a normal constituent of milk and comprises part of the nonprotein nitrogen fraction. Although opinions do vary to some extent, milk urea levels between 20 and 30 mg 100 mL^{-1} are generally considered as normal for cow's milk. Urea accounts for roughly 50% of the non-protein nitrogen fraction in herd bulk milk of dairy cows, although this may vary from 35 to 65%. For milk from individual cows, this variation may be even larger (Bijgaart, 2003). The urea content may be used to monitor nutritional status of lactating dairy cows and improve dairy herd nutrition.

The objective of this study was to evaluate the relation between milk protein and urea content in different farms with different holding technologies.

Materials and Methods

In the study, individual cow milk samples (n=8400) were collected monthly from four dairy farms (Farm A-D) from September 2009 to November 2010. Dairy herds represent three breeds: Holstein Black and White (HB), Latvian Brown (LB), and cross breed XP (cross breed from HB and LB). Average lactation number for cows in farm A was 2.37, farm B – 1.97, farm C – 3.47, and farm D – 2.16.

Dairy farms were with different number of animals in herds and with different milking and holding technologies. Farms A and C had a small (26 and 19 cows accordingly) number of animals and the traditional holding technology in the pasture-based seasonal dairying system. In these farms cows were managed in one feeding group. Whereas farms B and D were big farms (320 and 150 cows accordingly) with a balanced feeding and total mixed ration in all years without pasture period. Management in these farms was organized in feeding groups according to lactation stage. Milking frequency was two times per day. Farm B had one cow group with robotic milking. The herds were under official performance and pedigree recording.

The monthly control milk samples were analyzed for total protein, casein, fat, lactose, and urea content. All parameters were analyzed in accredited milk quality laboratory SIA 'Piensaimnieku Laboratorija' with instrumental infrared spectroscopy method with FOSS instrument CombiFoss FC.

Data regarding breed of cows and date of milk analysis were available from monthly records of the herds from state agency "Agricultural Data Centre" program.

Control day milk yield was grouped into six levels: 1st – ≤ 15.0 kg, 2nd – from 15.0 to 19.9 kg, 3rd – from 20.0 to 24.9 kg, 4th – from 25.0 to 29.9 kg, 5th – from 30.0 to 34.9 kg, and 6th – 35 kg and more.

The statistical analyses were performed using SPSS program package and Microsoft Excel for Windows.

The obtained data were analyzed using descriptive statistics and Pearson correlation analysis. The significance of the differences between the samples was assessed using ANOVA.

Results and Discussion

The study results were analyzed separately for each farm to evaluate cow milk productivity traits in the different farms (Table 1).

Table 1

Average milk productivity and quality traits during the research

Traits	Farms			
	A (n=387)	B (n=5539)	C (n=280)	D (n=2194)
Milk yield, kg	24.4 ± 0.35^a	23.1 ± 0.10^b	16.0 ± 0.34^c	26.8 ± 0.19^d
Protein content, g kg^{-1}	3.32 ± 0.021^a	3.62 ± 0.006^b	3.61 ± 0.031^b	3.49 ± 0.009^c
Casein content, g kg^{-1}	2.57 ± 0.015^a	2.78 ± 0.004^b	2.74 ± 0.023^b	2.68 ± 0.006^c
Fat content, g kg^{-1}	4.14 ± 0.042^a	4.55 ± 0.014^b	4.49 ± 0.053^b	4.09 ± 0.016^a
Lactose content, g kg^{-1}	4.70 ± 0.009^a	4.81 ± 0.002^b	4.69 ± 0.016^a	4.78 ± 0.005^c
Urea content, mg 100 mL^{-1}	21.3 ± 0.35^a	26.4 ± 0.13^b	42.6 ± 0.86^c	26.2 ± 0.15^b

$^{a, b, c, d}$ – milk productivity and quality traits with unequal letter, difference significantly between farms ($p<0.05$)

Average cow milk yield in farms significantly differed (from 26.8 to 16.0 kg per control day). The lowest milk yield was in farm C with LB breed cows, where cows were managed in one feeding group. The highest milk yield was in farm D with several breeds' cows, from which HM breed cows predominated and management in this farm was organized in feeding groups according to lactation stage.

Between farms was statistical significantly difference in milk constitute and quality. The farm B cow milk had highest protein, fat, casein and lactose content (3.62 g kg^{-1}, 4.55 g kg^{-1}, 2.78 g kg^{-1}, and 4.81 g kg^{-1}). Farm B had LB and HB breed cows, and management in this farm was organized in feeding groups according to lactation stage.

The average cow milk protein (3.57 g kg^{-1}) and fat (4.41 g kg^{-1}) content for all farms was higher than average milk recording results in Latvia in the year 2010 (3.31 and 4.29 g kg^{-1} accordingly).

The urea content in farms ranged between 21.3 and 42.6 mg 100 mL^{-1}. The average urea content in farm C was significantly higher (42 mg 100 mL^{-1}) than in other farms, which indicates problems in cow feeding balance and management. Also Lithuanian researchers (Savickis et al., 2010) have established influence to urea content in cow milk from farm.

The next in study were established that total protein and urea content in milk had influence from milk yield level and farms (Table 2).

Table 2

Average protein and urea content in milk of cows with different milk yield per day

Farms	Traits	Milk yield, levels					
		1 (≤15.0)	2 (15.0-19.9)	3 (20.0-24.9)	4 (25.0-29.9)	5 (30.0-34.9)	6 (35.0 ≥)
A	Protein, g kg^{-1}	3.93±0.077 ^{a}	3.58±0.039 ^{b,A}	3.32±0.029 ^{c,A}	3.18±0.029 ^{d,A}	3.03±0.040 ^{e,A}	3.00±0.561^{e,A}
	Urea, mg100 mL^{-1}	19.4±1.37 ^{A}	20.5±0.72 ^{A}	21.9±0.64 ^{A}	21.2±0.72 ^{A}	22.4±1.05 ^{A}	22.2±1.43 ^{A}
B	Protein, g kg^{-1}	4.07±0.019$^{a, A}$	3.80±0.010 ^{b,B}	3.58±0.088 ^{c,B}	3.46±0.009 ^{d,B}	3.34±0.011 ^{e,B}	3.20±0.016 ^{f,B}
	Urea, mg100 mL^{-1}	23.3±0.31 ^{a,B}	25.3±0.27 ^{b,B}	26.3±0.25 ^{c,B}	28.1±0.28 ^{d,B}	27.5±0.37 ^{d,B}	29.4±0.52 ^{e,B}
C	Protein, g kg^{-1}	3.91±0.043 ^{a,B}	3.39±0.043 ^{b,C}	3.29±0.032 ^{b,A}	3.22±0.032 ^{b,A}	3.40±0.204 ^{b,B}	-
	Urea, mg100 mL^{-1}	37.8±0.93 ^{a,C}	44.8±1.65 ^{b,C}	45.4±2.31 ^{b,C}	57.2±4.17 ^{c,C}	63.9±3.54 ^{c,C}	-
D	Protein, g kg^{-1}	3.95±0.039^{a,B}	3.72±0.019 ^{b,D}	3.56±0.017 ^{c,B}	3.44±0.015 ^{d,B}	3.33±0.016 ^{e,B}	3.21±0.013 ^{f,B}
	Urea, mg100 mL^{-1}	23.3±0.49 ^{a,B}	24.4±0.39 ^{a,B}	26.2±0.32 ^{b,c,B}	27.2±0.31 ^{c,B}	27.4±0.36 ^{c,B}	26.7±0.31 ^{c,C}

$^{a, b, c, d, e, f}$ – milk productivity and quality traits with unequal letter, difference significantly between milk yield levels group ($p<0.05$);

$^{A, B, C, D}$ – milk productivity and quality traits with unequal letter, difference significantly between farms ($p<0.05$).

The average protein content was higher and significantly different in first milk yield level in all farms. Observed decrease in second milk yield level (15.0 – 19.9 kg) of the average protein content, but it was highest than third till sixth milk yield level and significantly different in farms A, B and D. A significant difference between six yield levels was establish in farms B and D where higher average cow milk protein content (4.07 and 3.95 g kg^{-1} accordingly) was in first milk yield level, gradually decreasing to sixth milk yield level.

The milk urea content was significantly different in farms A and C in all milk yield levels, but no difference was observed of cow milk in farm B and D. Difference in milk urea content between milk yield levels was not observed in farm A. It should be pointed out that the average milk urea content had tendency to increase in all study farms from first milk yield level (≤15.0 kg) to the sixth (35.0 kg and more). The results of this study confirm previous researcher (Oltner et al., 1985) that milk yield still higher than milk urea content increase.

To evaluate relation between cow milk protein and urea content was estimated correlation in all farms and milk yield levels (Table 3).

Overall, in different farm and milk yield levels correlation between cow milk protein and urea content was low or very low. Average closely negative significant correlation (-0.491) was in farm A for cows with milk yield level up to 15 kg. These are stronger correlations than those reported by J.D. Ferguson et al. (1997) -0.138 for milk protein content. In farms B and D, for the same milk yield level, a very low significantly positive correlation (0.129 and 0.229 accordingly) was observed. Correlation was closely negative (-0.449) in farm C with milk yield level from 30 to 35 kg.

Table 3

Correlation between cow milk protein and urea content in farm and milk yield level

Farms	Milk yield, levels					
	1 (≤15.0)	2 (15.0-19.9)	3 (20.0-24.9)	4 (25.0-29.9)	5 (30.0-34.9)	6 (35.0 ≥)
A	-0.491**	-0.097	0.080	0.053	0.138	0.013
B	0.129**	-0.030	0.041	0.028	0.011	0.012
C	0.075	0.146	0.353*	-0.341	-0.449	-
D	0.229**	0.154**	0.021	0.014	-0.034	-0.017

*$p<0.05$, **$p<0.01$.

Researchers (Eicher et al., 1999) have observed the relationships between milk urea and protein content in respect of the factors parity, daily milk yield and days postpartum also vary considerably among herds. E.Z.M. Oudah (2008) confirms a very low negative correlation among milk protein and urea content in the lower test-day milk yield. Canadian researchers have found negative relationships between milk protein and milk urea nitrogen content in dairy cow milk (Arunvipas et al., 2003). Whereas W. Richardt (2002) has established positive correlation among milk protein and urea content in the cow milk.

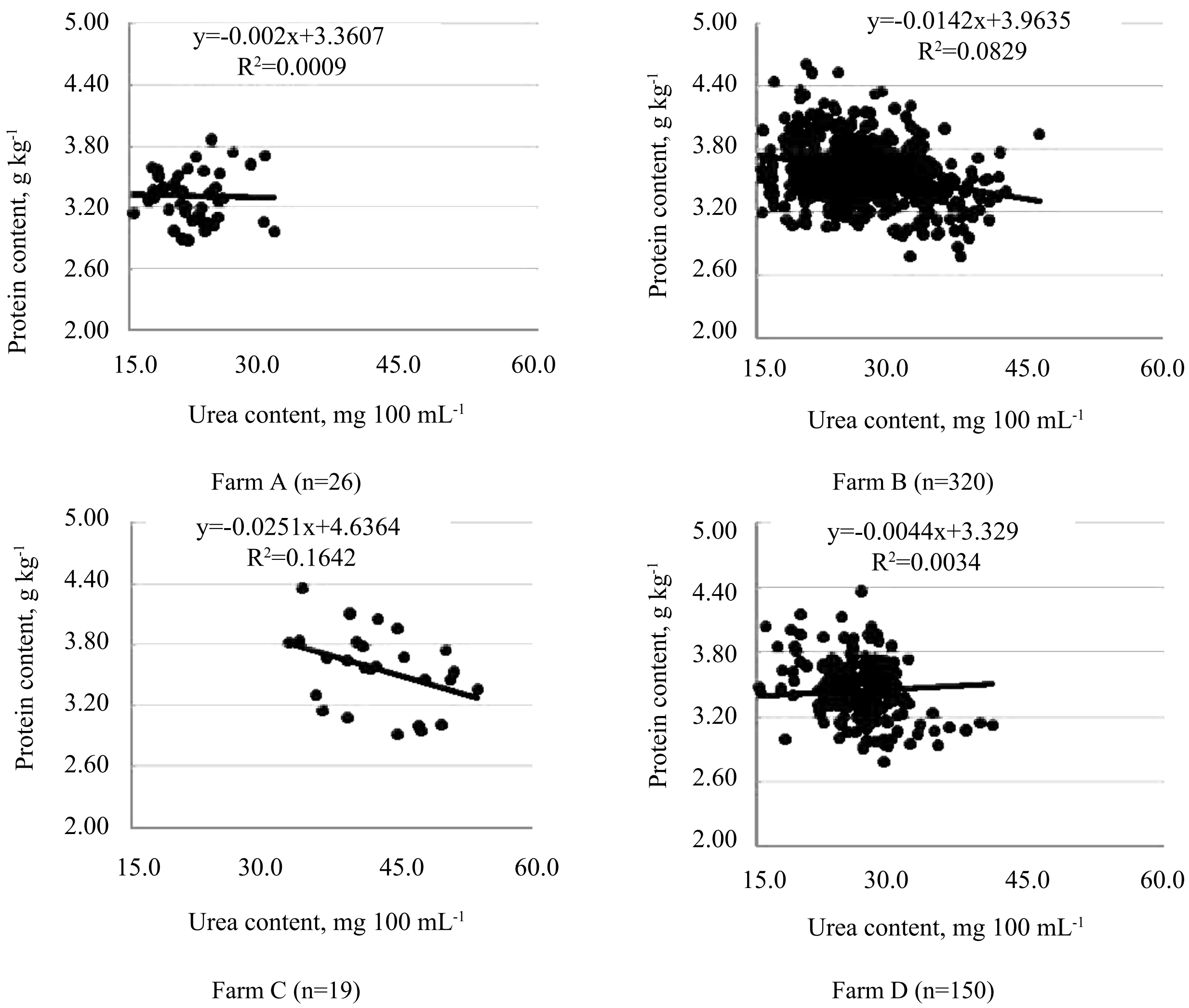

Figure 1. Relationship between average individual cow milk protein and urea content during research.

Many researchers (Depeters and Cant, 1992; Bijgaart, 2003) confirm that normal milk urea content in milk is from 15.0 to 30.0 mg 100 mL^{-1}. The measurements of milk urea content could be used to assess the adequacy of protein feeding in dairy cows and the efficiency of N utilization for milk production (Jonker et al., 1998; 2002; Nousiainen et al., 2004). Basing on measurements from each farm and average cow milk protein and urea content for each cow in a farm, the relationship between them was estimated. In farm C, average milk urea content varied between 30.0 and 60.0 mg 100 mL^{-1}, which indicates problems in feeding or management in the farm (Figure 1). In farm B, significantly influence milk protein content from milk urea content varied that suggest regression analyze (R^2=0.0829).

Conclusions

1. It was established that milk productivity traits significantly ($p<0.05$) varied in farms with different dairy cow holding and feeding technologies.
2. In farms A, B, and D, milk urea content was not higher than the allowable level (from 15.0 to 30.0 mg 100 ml^{-1}) which suggests about balanced feeding or good management in the farm.
3. The milk protein and urea content significantly ($p<0.05$) varied for cows with different milk yield per day the cow with the highest milk yield had the lowest protein and highest milk urea content.
4. The evaluation between milk protein and urea content were significant from low negative (r=-0.491) to low positive (r=0.353) was established.
5. In farm B, variations in milk urea content significantly influenced changes in milk protein content, which was confirmed by regression analysis (R^2=0.0829).

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