

RELATION OF UDDER QUARTER DEVELOPMENT WITH DAILY MILK YIELD, COMPOSITION AND SOMATIC CELL COUNT

Evaldas Šlyžius¹, Vida Juozaitienė¹, Saulius Tušas², Arūnas Juozaitis³, Judita Žymantienė⁴¹*Department of Animal Breeding, Veterinary Academy, Lithuanian University of Health Sciences
Tilžės 18, LT-47181 Kaunas, Lithuania; Tel. +370 37 363575; E-mail: biometrija@lva.lt; slyzius@lva.lt*²*Department of Animal Husbandry, Veterinary Academy, Lithuanian University of Health Sciences
Tilžės 18, LT-47181 Kaunas, Lithuania*³*Department of Animal Nutrition, Veterinary Academy, Lithuanian University of Health Sciences
Tilžės 18, LT-47181 Kaunas, Lithuania*⁴*Department of Anatomy and Physiology, Veterinary Academy, Lithuanian University of Health Sciences
Tilžės 18, LT-47181 Kaunas, Lithuania*

Abstract. The aim of this study was to investigate the impact of the development of udder quarters on cow productivity and milk composition and somatic cell count in milk. The rear quarters produced more milk with higher fat, protein and lactose content than the front quarters but in urea content there was no difference between the front and the rear quarters. The front quarters produced 41.8 % of the total yield, and rear quarters produced 58.2 % ($p < 0.001$). Front teats were longer than rear teats. The diameter of the rear teats was smaller than that of the front teats. The difference of the distance between the front and the rear teats was 7.49 cm, while the distance difference between the left and the right teats was insignificant and amounted to 0.29 cm ($p < 0.001$). The distance between the front teats was 2.52 times higher than the distance between the rear teats. In addition, the distance between teats is subject to considerable variation (22–60 %) and shows the need to increase the intensity of selection. Significant correlation of milk yield and SCC with teat thickness, teat length and teat distance measures was established.

Keywords: cow, somatic cell count, milk, udder quarters, teats.

TEŠMENS KETVIRČIŲ IŠSIVYSTYMO RYŠYS SU KARVIŲ PRODUKTYVUMU, PIENO SUDĖTIMI IR SOMATINIŲ LAŠTELIŲ SKAIČIUMI

Evaldas Šlyžius¹, Vida Juozaitienė¹, Saulius Tušas², Arūnas Juozaitis³, Judita Žymantienė⁴¹*Gyvūnų veisimo katedra, Veterinarijos akademija, Lietuvos sveikatos mokslų universitetas
Tilžės g. 18, LT-47181 Kaunas; tel. (8-37) 36 35 75; el. paštas: biometrija@lva.lt; slyzius@lva.lt*²*Gyvulininkystės katedra, Veterinarijos akademija, Lietuvos sveikatos mokslų universitetas
Tilžės g. 18, LT-47181 Kaunas*³*Gyvūnų mitybos katedra, Veterinarijos akademija, Lietuvos sveikatos mokslų universitetas
Tilžės g. 18, LT-47181 Kaunas*⁴*Anatomijos ir fiziologijos katedra, Veterinarijos akademija, Lietuvos sveikatos mokslų universitetas
Tilžės g. 18, LT-47181 Kaunas*

Santrauka. Šio darbo tikslas buvo ištirti tešmens ketvirčių išsivystymo įtaką karvių produktyvumui, pieno sudėčiai ir somatinių laštelėlių skaičiui piene. Iš užpakalinių ketvirčių buvo primelžta pieno daugiau, nei iš priekinių. Riebalų, baltymų ir laktozės daugiau buvo užpakalinių tešmens ketvirčių piene. Urėjos kiekis iš skirtingų tešmens ketvirčių primelžtame piene nesiskyrė. Iš priekinių ketvirčių buvo primelžta 41,8 proc., o iš užpakalinių – 58,2 proc. viso primelžto pieno kiekio ($p < 0,001$). Priekiniai speniai buvo ilgesni ir storesni nei užpakaliniai. Atstumo skirtumas tarp priekinių ir užpakalinių spenių buvo 7,49 cm, tuo tarpu atstumo skirtumas tarp kairės ir dešinės pusės spenių buvo nežymus – iki 0,29 cm ($p < 0,001$). Nustatytas atstumas tarp priekinių spenių yra net 2,52 karto didesnis nei užpakalinių. Be to, atstumo tarp spenių variacija yra ženkli (22–60 proc.) ir rodo selekcijos intensyvinimo būtinybę. Nustatyta patikima pieno kiekio bei SLS koreliacija su spenių storiumi, spenių ilgiu ir atstumo tarp spenių matais.

Raktažodžiai: karvė, somatinių laštelėlių skaičius, pienas, tešmens ketvirčiai, speniai.

Introduction. Data on milk components and milk yield provide information on milk quality alterations and cow health status (Forsbäck et al., 2010).

The udder consists of four separate quarters and when milk sampling for somatic cell count (SCC) analyses is performed at the whole udder level, an increase in SCC in one quarter may be masked by the dilution effect from the other, healthy quarters. Therefore, such udder quarters may be important to detect (Berglund et al., 2007).

Fat content in milk could be an indicator of feeding and milking because it is highly dependent on the amount of fibre in the diet and on udder emptying (Bauman and Griinari, 2003; Forsbäck et al., 2010; Nielsen et al., 2005). Protein in milk is highly dependent on the genetic capacity of the cow but can be altered by factors such as stage of lactation and udder health (Auld et al., 1996; Forsbäck et al., 2010; Urech et al., 1999). Information on fat and protein levels is used for the planning of feeding

strategies and in breeding (Forsbäck et al., 2010). Milk yield and milk composition are the parameters that change in relation to changes in SCC. Even slightly increased SCC is associated with a decrease in milk yield (Berglund et al., 2007). The urea content of a cow's milk depends largely on nutritional factors (Arunvipas et al., 2003) and can provide valuable information on herd nutrition and metabolic disorders and the physiological status of cows (Collard et al., 2000; Purwin et al., 2005; Savickis et al., 2010).

Individual milkability at an udder level is a complex characteristic that is determined by the milkability at quarter levels and the distribution of quarter milk yields. The anatomical and functional characteristics of single teats can partly explain the milk flow characteristics of individual quarters (Weiss et al., 2004).

Udder and teat morphology is highly heritable (Seykora and McDaniel, 1986; Rogers and Spencer, 1991) and could serve as a marker trait for selection to reduce mastitis in dairy cattle (Rogers and Spencer, 1991). The understanding of the relationship between morphological characteristics of udders, milking traits and milk yield as well as the quality of cows can help to introduce new aspects in the current dairy cattle breeding schemes. Positive associations between udder parameters and milk performance of dairy cows have been reported in most sources (Kuczaj et al, 2000, 2003; VanRaden et al, 1990).

The aim of this study was to investigate the impact of the development of udder quarters on cow productivity and milk composition and somatic cell count in milk.

Material and methods. The scientific research was carried out between 2009 and 2011 at the Animal Breeding Research and Breeding Value Laboratory of the Department of Animal Breeding of the Veterinary Academy, the Lithuanian University of Health Sciences, and at a dairy farm. The study evaluated 225 cows and 900 udder quarters were tested.

A total of 225 Lithuanian Black and White cows, in their first to sixth lactation, were investigated. The cows were milked twice daily at 6.00 a.m. and 5.00 p.m. The cows were milked during the 2nd – 6th months of lactation with the Russian Agriculture electrification institute

udder's quarter milking device "YPB-1". The daily quantity of milk was measured and milk samples taken from the milking. Milk analyses were carried out in SE "Pieno tyrimai". Milk fat (%), protein (%), lactose (%) and urea (mg%) were determined using the testing device "LactoScope FTIR" (FT1.0. in 2001, Delta Instruments, Netherlands) SCC (thousand/ml) was determined using a device "SomaScope" (CA-3A4, 2004, Delta Instruments, Netherlands).

The current study was aimed at measuring the morphological parameters of the udder quarter (cm): teat length, teat thickness, the distance between the front teats, the distance between the rear teats, the distance between the right half teats and the distance between the left half teats.

The research was carried out in accordance with Animal Care, Storage and Use Act No. 8-500, November 6, 1997, of the Republic of Lithuania, ("Valstybės žinios", No. 108 of November 28, 1997).

Descriptive statistics: the average of investigated traits (M), standard errors (SE), the coefficient of variations (CV) and correlation (r) between signs were calculated using the SPSS (license no. 9900457, version 15, SPSS Inc., Chicago, IL) statistical package of Animal Breeding Value Breeding and Research Laboratory of the Veterinary Academy of the Lithuanian University of Health Sciences. The results are considered reliable at $p < 0.05$.

Results and discussion. The ever increasing automation of the milking equipment increases the demands placed upon the adequacy of the udder for automatic milking. Therefore, the equal development of quarters is very important. The means, standard errors and ranges for milk yield and content per quarter are presented in Table 1. The rear quarters produced more milk with higher fat, protein and lactose content than the front quarters. As far as urea content was concerned there was no difference between the front and the rear quarters. The quarters had similar milk production, fat, protein, urea and lactose results which agree with the previous findings (Ayadi et al., 2004; Berglund et al., 2007; Tančin et al., 2007; Weis et al., 2004).

Table 1. Milk yield and milk content in udder quarters

Parameters	Milk, kg	SCC, thousands/ml	Protein, %	Fat, %	Lactose, %	Urea, mg %
Right front ^a	2.71 ± 0.10 ^{***dc}	300.04 ± 43.97 ^{*c}	3.08 ± 0.03	4.10 ± 0.07	4.76 ± 0.02	26.18 ± 1.01
Left front ^b	2.63 ± 0.08 ^{***dc}	371.45 ± 69.12	3.08 ± 0.03	4.19 ± 0.07	4.77 ± 0.02	25.97 ± 1.01
Front ^c	5.34 ± 0.16 ^{***f}	335.75 ± 42.53 ^{***f}	3.08 ± 0.03	4.15 ± 0.07	4.77 ± 0.02	26.09 ± 0.99
Right rear ^d	3.47 ± 0.09 ^{***ab}	356.16 ± 61.36	3.11 ± 0.03	4.18 ± 0.07	4.79 ± 0.02	26.55 ± 1.02
Left rear ^e	3.42 ± 0.09 ^{***ab}	383.35 ± 62.27 ^{*a}	3.11 ± 0.03	4.24 ± 0.08	4.78 ± 0.03	26.02 ± 1.02
Rear ^f	6.89 ± 0.17 ^{***c}	369.76 ± 52.47 ^{***c}	3.11 ± 0.03	4.21 ± 0.07	4.79 ± 0.03	26.30 ± 1.01

^{abcdef} Means with different superscript letters indicate significant differences between quarters.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

The LR (left rear) and RR (right rear) quarters produced 3.42 and 3.47 kg while LF (left front) and RF (right front) quarters produced 2.63 and 2.71 kg of milk.

The front quarters produced 41.8% of the total yield, and rear quarters produced 58.2% ($p < 0.001$) (Fig. 1). Similar proportions for front quarters of 40 % have been reported

by Bach and Busto (2005) and 44.27 % by Tančin et al. (2007).

Tančin et al. (2007) examined the differences among quarters for yield per quarter and proportion per quarter. RF and LF quarters produced 22.04 % and 22.23 % of the total yield, whereas RR and left LR quarters produced 28.24 % and 27.49 %. Weiss et al. (2004) found that front quarters produced 39.4% and rear quarters produced 60.6 % of total yield.

Right quarters produced 50.53 % of the total yield, and left quarters produced 49.47 % ($p < 0.001$) (Fig. 2). Similar proportions for left quarters of 50.97 % have been reported by Weiss et al. (2004) and 49.71 % by Tančin et al. (2007). Tančin et al. (2007) found that right quarters produced 50.29 % and left quarters produced 49.71 % of total yield.

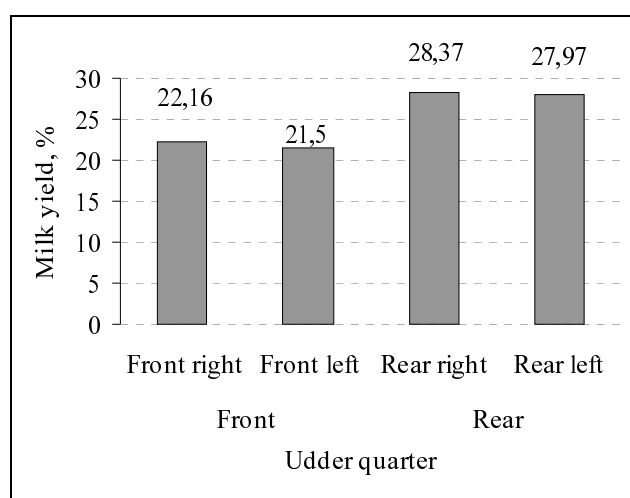


Fig. 1. Milk yield in the front and the rear udder quarters

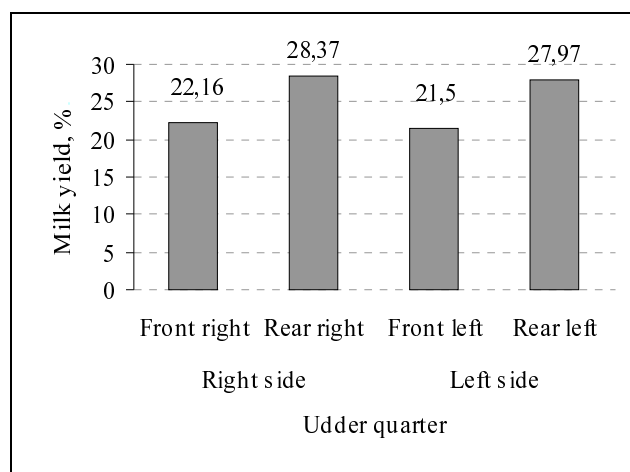


Fig. 2. Amount of milk in the right and the left udder quarters

Therefore, the anatomical and functional characteristics of the teat would be expected to have considerable effects on milking performance of the individual quarter and cow (Weiss et al., 2004).

According to earlier studies, teat canal measurements are related to milk yield (Kuczaj et al., 2000; Rogers and Spencer, 1991; Weiss et al., 2004) and udder health (Grindal et al., 1991; Kuczaj, 2003; Núñez et al., 2006).

Front teats were longer than rear teats (Table 2). The diameter of the rear teats was smaller than that of the front teats. Teat length and teat diameter measurements were similar to those in similar studies (Kuczaj et al., 2000; Seykora and McDaniel, 1986). Other investigations reported longer and thicker teats (Rogers and Spencer, 1991; Weiss et al., 2004).

The distance between the teats is examined in Fig. 3. According to the results of this study, the difference of the distance between the front and rear teats was 7.49 cm, while the distance difference between the left and right teats was insignificant and amounted to 0.29 cm ($p < 0.001$). Fig. 3 shows the unevenness of the development of udder quarter. The distance between the rear teats is 2.52 times higher than the distance between the front teats. In addition, the distance between teats is marked by considerable variation (22–60 %) and shows the need to increase the intensity of selection. Kuczaj et al. (2000) and Rogers and Spencer (1991) report similar results, the distance between the rear teats being higher than the distance between the front teats, respectively, 2.5 and 2.1 times in cows they have studied.

Table 2. The length and thickness of the udder quarters teats

Quarters	M ± SE	Cv
Teat length, cm		
Right front ^a	5.46 ± 0.08 ^{***bde}	22.05
Left front ^b	5.05 ± 0.09 ^{***ac}	25.46
Front ^c	5.22 ± 0.07 ^{***f}	20.75
Right rear ^d	5.06 ± 0.08 ^{***a}	20.75
Left rear ^e	4.63 ± 0.08 ^{***ab}	24.77
Rear ^f	4.84 ± 0.07 ^{***c}	21.24
Average	5.03 ± 0.06	19.28
Teat thickness, cm		
Right front ^a	2.30 ± 0.02 ^{***c}	15.20
Left front ^b	2.25 ± 0.02	15.95
Front ^c	2.27 ± 0.02 ^{*f}	14.30
Right rear ^d	2.25 ± 0.02	15.14
Left rear ^e	2.22 ± 0.02 ^{***a}	14.19
Rear ^f	2.24 ± 0.02 ^{*c}	13.59
Average	2.26 ± 0.02	13.27

^{abcdef} Means with different superscript letters indicate significant differences between quarters.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

The correlation analysis (Table 3) showed that there is a statistically significant positive correlation ($r = 0.167$, $p < 0.05$) between the amount of the milk yield and udder index. Negative correlations were observed between somatic cell count and milk yield ($r = -0.096$).

Analyzing the relationship between milk yield, SCC and the morphological characteristics of the teats, the largest positive correlation coefficient was found between

milk yield and the distance between the front teats ($r = 0.210$, $p < 0.01$) also between milk yield and left half of the teats ($r = 0.210$, $p < 0.01$).

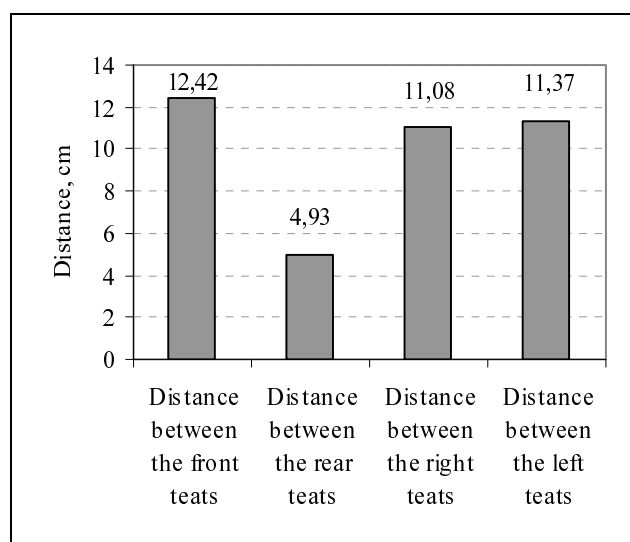


Fig. 3. Distance between teats

There was a significant correlation between SCC and milk composition; the correlation between the SCC and milk yield, lactose content, respectively, was negative while the correlation between SCC, and fat and protein content, respectively, was positive.

The negative correlation between milk yield and the SCC was observed by Berglund et al. (2007) and Nauman et al. (1998). Other studies have shown a similar relationship between morphological characteristics and udder milk yield (Kuczaj et al., 2000; Tilkin et al., 2005) and the SCC (Kuczaj et al., 2003; Kul and Erdem, 2008).

Table 3. Correlation analysis

Traits	Milk yield, kg	SCC
Milk yield, kg	-	-0.096
Protein, %	-0.189**	0.168*
Fat, %	-0.183**	0.098
Lactose, %	0.161*	-0.332**
Urea, mg %	0.154*	0.056
Udder index, %	0.167*	0.049
Teat length, cm	0.096	0.185**
Teat thickness, cm	0.193**	-0.077
Distance between the front teats, cm	0.210**	0.142*
Distance between the rear teats, cm	0.126	0.165*
Distance between the right teats, cm	0.173*	0.099
Distance between the left teats, cm	0.210**	0.118

* $p < 0.05$; ** $p < 0.01$

Conclusion

1. Our study confirmed previous findings that rear udder quarters produce by 16.4 % more milk than the front udder quarters. The right and left half of the udder

quarters did not differ.

2. The distance between the front teats was 2.52 times greater than the distance between the rear teats, so it can be concluded that an appropriate selection according to udder development is advisable.

3. Milk yield and the SCC significantly correlated with teat thickness, teat length and teat distance measures.

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