DEPENDENCE OF DAIRY COWS MILKABILITY TRAITS ON GENOTYPE

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Abstract. The aim of this work was to evaluate milk flow traits of Lithuanian Black and White dairy cows and to estimate their dependence on genotype according to the Holstein breed degree and relation to the productivity of milk. The study was performed on a total of 314 Lithuanian Black and White cows during their 2–4 months of lactation. Sixteen milk flow traits were evaluated with LactoCorder®. The average milk yield of cows was 13.346±0.222 kg, milk flow 2.174±0.036 kg/min^{-1}, and the highest milk flow rate 3.319±0.052 kg/min^{-1}. The average duration of the incline phase was 0.788±0.022 min, the duration of the plateau phase was 2.220±0.075 min, and the duration of the decline phase was 3.251±0.123 min. The increase of the Holstein breed degree showed a positive relation with milking speed and milk yield ($P<0.01$) and a negative relation with bimodality ($P<0.0001$).

Keywords: milkability, milk flow curves, LactoCorder®, Holstein breed degree, bimodality

Introduction. Milkability can be considered as an important functional trait in dairy cattle with regard to udder health (Mijić et al., 2004). Dairy farmers place considerable emphasis on milkability, because low-milking cows hinder the milking process of the herd (Krogmeier et al., 2006). Milk flow traits can have a great effect on the culling rate (Bagnato et al., 2003).

With a view to improving cow health and productivity, it is, therefore, important that electronic milk flow meters should be used to analyse milk flow curves (Sandrucci et al., 2007). The LactoCorder®, a mobile milk meter, is used for routine dairy recording in dairy herds. This milk meter calculates milk flow during milking. The LactoCorder® can be used as a diagnostic tool for evaluating milking procedure problems (Tamburini et al., 2007).

For many decades, Holstein cattle have been used in other dairy cattle breeding to increase milk production. Schaeffer et al. (2011) studies have shown that crossbred cows in Canada produce less milk but more fat and protein than purebred Holsteins.

Many studies (Lee and Choudhary, 2006; Strapák et al., 2009; Strapák et al., 2011; Schaeffer et al., 2011; Muller et al., 2011) with Holstein cows have shown that cow milk yield is associated with milking speed and milking duration; therefore, shortened milking time may negatively affect the total amount of milk. Strapák et al. (2011) determined that the total milk yield of Holstein cows revealed a positive correlation with average ($r = 0.48$; $P<0.001$) and maximum ($r = 0.32$; $P<0.001$) milk flow rates, and the average milk flow rate was most influenced by the duration of the main phase of milking and by the total milk yield. Due to the fact that the Holstein breed is known as the world's highest-production dairy animals (Heins et al., 2006), they have been used in Lithuania in breeding improvement programmes of Black and White dairy cattle (Jukna, Pauliukas, 2001).

Lee and Choudhary's (2006) studies with Holstein cows showed that time at plateau (tPL) and decline (tAB) phases had an important contribution to the total (MGG) or main milking (tMHG) suggesting that tPL and tAB concludes the major part of the total milking time. Negative correlation of MG2 and MG3 with MGG and tMHG suggests a reduction in milking time with an increase in the milk yield during the second and third minute of milking.

The high occurrence of bimodal curves shows the faults during preparation before milking and insufficient expression of the ejection reflex (Strapák et al. 2009). Strapák et al. (2011) detected a higher total milk yield (12.34±3.42 kg) and average milk flow rate (2.56±0.81 kg/min^{-1}) in the group of cows without bimodality.

The cows with bimodal curves reached a more than twice longer incline phase of milking and a lower amount of milk obtained during the first minute of milking, and it is connected with the beginning of the milking process. Strapák et al. (2011) used the t test and detected that the traits of the amount of milk obtained during the first minute of milking and the main and the plateau phase of milking were significantly ($P<0.001$) different between Holstein dairy cows with and without bimodal curves.

The objectives of this research were to evaluate the milkability traits of Lithuanian Black and White dairy cows and to estimate their dependence on genotype according to the Holstein breed degree.

Material and methods. The research was carried out in farms of the Lithuanian Black and White Cattle Breeders Association, State Laboratory for milk control

'Pieno tyrimai', State Enterprise 'Agriculture Information and Rural Business Developement Centre', and the Animal Breeding Research and Breeding Values Laboratory of the Lithuanian University of Health Sciences. Sixteen milk flow traits of 314 Lithuanian Black and White cows were evaluated in 2–4 months of lactation with average 2.8±0.06 lactation.

Two groups of cows were selected according to the level of Holstein breed genes in the genotype of cows as follows: HF1 – with less than 75% (n=203) and HF2 – with 75% and more (n=111).

Milk flow measurements were carried out with a continuous electronic mobile milk meter (LactoCorder®, WMB, Balgach, Switzerland).

The following parameters were evaluated during the research: the total milk yield from start to the end of the milking process (MGG); milk yield during the first minute of milking (1 MG); milk yield during the first 2 minutes of milking (2 MG); milk yield during the first 3 minutes of milking (3 MG); milk yield during stripping (MNG); maximum milk yield measured within a time interval of 1 minute (HMG); the total milking time (tMGG); time until the milking phase (t400); time of incline in milk flow from 0.5 kg/min to the reach of the plateau phase (tAN); time at the plateau phase, i.e. with constant milk flow (tPL); time at the decline phase (tAB); time of the main milking process (tMHG); time at stripping (tMNG); the highest milk flow measured within a time interval of 22.4 seconds (HMF); the average main milking process per minute (DMHG); and bimodality (%), i.e. a steep decrease of milk flow in time up to 96 seconds after the beginning of milking (BIMO).

The database (PostgreSQL) for data manipulation and analysis was created at the Animal Breeding Research and Breeding Values Laboratory using the open source data operating system LINUX Redhat 6.2 OS.

The percent of Holstein genes in the cows' genotype was estimated according to the cows' records with complete (3 generations of ancestor) pedigree information. The results of the measurements with LactoCorder® were processed by the software package LactoPro 5.2.0 (Biomelktechnik Swiss).

The t test was used in order to detect significant differences between the compared groups. Descriptive statistics (mean±standard error) and the Pearson chi-squared test ($\chi 2$) were calculated using R 2.1.0 package (http://www.r-project.org/). The results were considered to be reliable under $P \leq 0.05$.

Results. The average Hostein breed degree in genotype of cows was 68.2%. The higher MGG and HMG were observed in cows with a higher Holstein breed degree (Table 1). The increasing value of the Holstein breed degree shows a relation to the traits of milking flow, i.e. DMHG and HMF.

Table 1. **Milk production and milking properties of cows**

Group of cows	MGG	tMGG	DMHG	HMF	HMG
HF1	12.63±0.197	8.15±0.203	2.04±0.041	3.17±0.060	3.04±0.060
HF2	14.66±0.313*	8.15±0.264	2.41±0.062*	3.60±0.093*	3.52±0.091*
*P<0.001					

MGG 13.85%, HMG 15.79%, DMHG 15.35%, and HMF 11.94% were higher in cows with a higher Holstein breed degree (Group HF2) than in cows with a lower Holstein breed degree (Group HF1), (P<0.001). The tMGG in both groups of cows was the same.

Higher milk yield 1 MG, 2 MG and 3 MG were estimated in cows with a higher Holstein breed degree (Figure 1). During the first 3 minutes of milking, 60.27% of the total milk was milked from cows of Group HF1 and 61.01 % from cows of Group HF2.

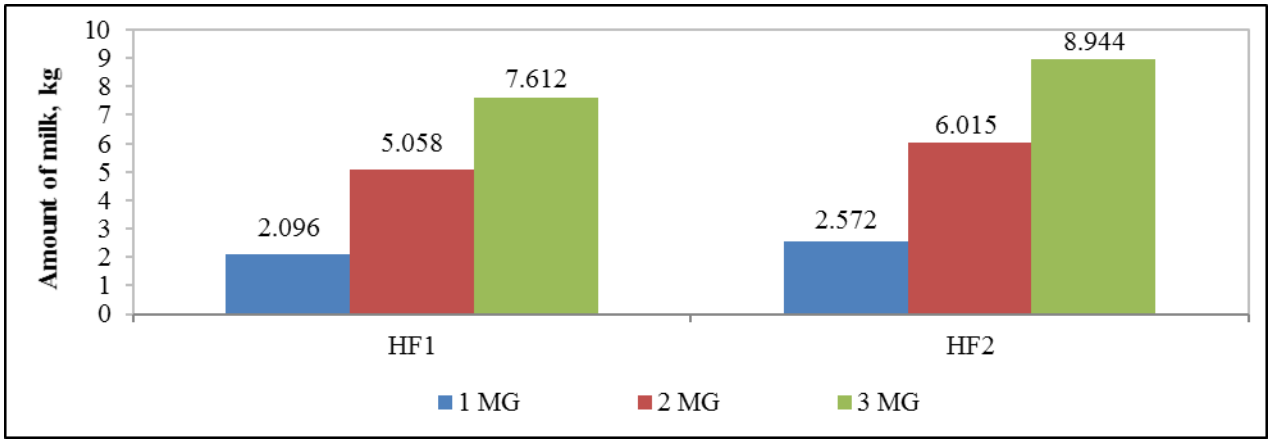

Fig. 1. **Milk yield in the first 3 minutes according to HF level of cows**

The greatest amount of milk was milked during the second milking minute. In the group of cows HF1, the average milk yield in the second minute of milking was 2.96 kg (58.56% more than during the first minute and 33.55% more than during the third minute), (P<0.001); and in Group HF2, it was 3.44 kg (57.24% more than

during the first minute and 32.75% more than during the third minute), (P<0.001).

Higher milk yield 1 MG (18.66%), 2 MG (15.91%) and 3 MG (14.89%) was estimated in cows with a higher Holstein breed degree (Group HF2), (P<0.001). Since the average time for reaching tAN in the present research was on average 0.78 min, it indicates that the cows are not getting proper stimulation before milking starts and, thus, the alveolar milk is not available earlier for milking, prolonging the total milking time, except for cows in Group HF2, but even in this group tAB lasted too long.

There were no significant differences between the groups by the Holstein breed degree for milk flow phase duration (Table 2). Higher milk flow phase duration was estimated in cows with a lower Holstein breed degree (group HF1), except for tPL and tMHG.

Table 2. **Traits of milking phases**

Group of cows	tAN	tPL	tAB	t400	tMHG	tMNG
HF1	0.82±0.028	2.11±0.093	3.32±0.153	0.22±0.013	6.26±0.182	1.20±0.057
HF2	0.72±0.033**	2.41±0.125*	3.12±0.205	0.21±0.015	6.26±0.243	1.10±0.058
*P<0.05, **P<0.001						

In cows with a higher Holstein breed degree (Group HF2), t400 (4.55%), tAN (12.2%), (P<0.001), tAB (6.02%), tMNG (8.33%) were shorter and tPL (12.45%) was longer than in cows with a lower Holstein breed degree (Group HF1), (P<0.05).

Figure 2 shows that bimodality was higher in cows with a lower Holstein breed degree. A significant relation between bimodality and the level of a Holstein breed degree ($\chi 2$ = 16.849; DF = 1; P<0.0001) was determined.

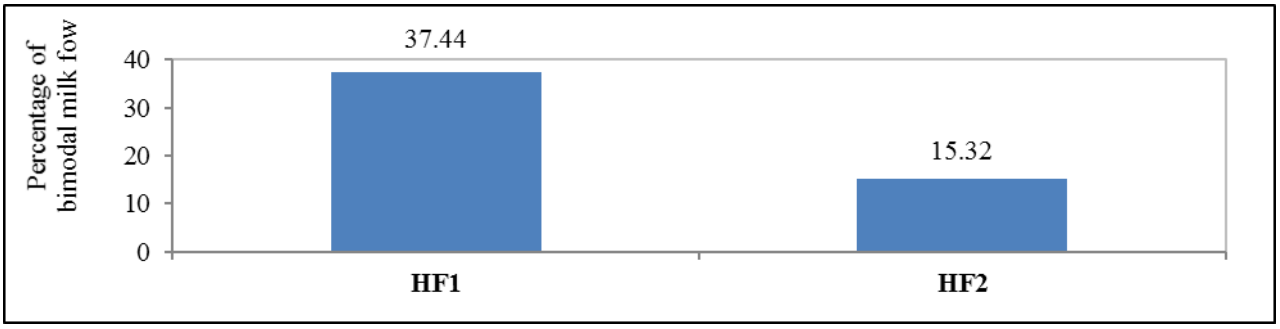

Fig. 2. **Bimodality of milk flow curves by HF level**

The bimodal milk flow curves were determined in 29.62% of cows (37.44% in Group HF1, 15.32% in Group HF2). A significant relation was determined between bimodality and the level of the Holstein breed degree (P<0.0001) of cows.

Discussion

Cows with a higher Holstein breed degree had a higher milk yield, which leads to a greater milk flow. During the first 3 minutes of milking, 60.27−61.01% of milk yield was milked from cows. Similar results were recorded by Lee and Choudhary (2006) in Holstein cows (total milk yield was 14.14 kg, and 62% of this milk was milked during the first 3 minutes of milking). The higher percentage (84.1%) of milk yield during the first 3 minutes of milking was reported by Strapák et al. (2016) in Slovak Spotted cattle. The selection of animals for higher MG2 and MG3 may improve the milkability of the herd. The proportion of MG2 or MG3 against MGG may be influenced by pre-stimulation (Lee, Choudhary, 2006).

Maximum (4.49 kg/min^{-1}) and average (2.84 kg/min^{-1}) milk flow of Holstein dairy cows were reported by Strapák et al. (2009), which is higher than the findings of the present research. The average HMG was 3.210 kg/min, which is in agreement with the value of 3.21 kg/min reported by Lee and Choudhary (2006). tMGG 8.149 min exceeded 7 min, which might have detrimental effects on teat conditions as reported by Neijenhuis et al. (2000).

Cho et al. determined a maximum milk yield of 2.94 kg/min in Holstein cows, which is a little lower than that of the present research. A higher Holstein breed degree (Group HF2) is associated with higher milk flow, which results in milk flow phases, except for tPL.

Selection for longer time at the plateau phase (tPL) would reduce the presence of bimodality and, thus, the need for longer udder prestimulation periods (Zucali et al., 2009; Gray et al., 2011).

Göft et al. (1994) announced that the tPL should last 4–5 minutes, whereas the tAB should not last any longer than 1 minute. In our research, these ranges were not reached (with average tPL of 2.220±0.075, and tAB 3.251±0.123 min). Muller et al. (2011) determined in their research on Holstein Friesian cows a short tAN (0.7 min), a relatively long tPL (3.5 min) and a shorter tAB (2.8 min).

Sandrucci et al. (2007) observed during their research on Italian Holstein-Friesian cows a short tAN (0.89 min), which showed a wide variability similar to the results of the present study. Since the average time for reaching tAN in the present research was 0.78 min, it indicates that

the cows are not getting proper stimulation before milking starts; therefore, the alveolar milk is not available earlier for milking, thus prolonging the total milking time, except for cows in HF2 of Group 2, and even in this group tAB lasted too long. The long tAB duration (2.710±0.253 min on average) is probably due to the sequential ending of milk ejection of less producing quarters; this result suggests the tendency to overmilk one or more quarters (Sandrucci et al., 2007).

The average milking time of cows analysed in both groups (HF1 and HF2) was the same, but a higher milk yield was determined in cows of Group HF2, which shows that cows with a higher Holstein breed degree (Group HF2) had a higher milk flow. Cows with high HMF are prefered by dairy farmers because of their shorter duration of milking, but the targeted selection of cows with high HMF cannot be recommended without consideration of the negative effect in regard to increased risk for mastitis and hygiene problems (Klaas et al., 2005).

In cows with a higher Holstein breed degree (Group HF2), the bimodal milk flow curves were lower 2.44 times, compared with a lower Holstein breed degree (Group HF1), ($P<0.0001$). Similar results to those of the present research were recorded by Sandrucci et al. (2007) (35.1%), Antalík and Strapák (2010) (32.98%).

Bimodal milk flow curves imply a non-continuous milk flow at the beginning of milking. Bimodality in the milk curve occurs due to improper stimulation or absence of pre-stimulation of cows (Ambord and Bruckmaier, 2009). Thus, it takes longer time to withdraw alveolar milk than the time at which the cistern milk is drawn out. Bimodality can affect udder health and teat condition (Rasmussen, 2004). In addition, bimodal milk flow curves can have negative effects on further milking process as temporary overmilking (Dzidic et al., 2004, Tančin et al., 2001).

Conclusions

Higher Holstein breed degree is associated with higher milk yield, milking speed and shorter phases of milk flow ($P<0.01$). The results confirm that the milk flow curve is a good tool to monitor cows' milking traits. It can help to detect mistakes in the milking routine, inadequate milking equipment, and is a significant tool in the evaluation of the cows' milking performance.

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