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RELATIONSHIP OF UDDER AND TEAT MORPHOLOGY TO MILKING CHARACTERISTICS AND UDDER HEALTH DETERMINED BY ULTRASONOGRAPHIC EXAMINATIONS IN DAIRY COWS*

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Abstract

The aim of this study is to call attention to the possibility of using ultrasonography as a useful tool for the evaluation of morphological characteristics of the udder and teats in dairy cows in relation to milking characteristics and udder health. A total of 26 dairy cows of the Holstein breed in the first (n = 13) and second lactation (n = 13) were investigated with a linear array ultrasound probe. Recovery of the teat internal parameters after milking was determined by ultrasonographic scanning. Teat canal length, teat canal diameter and teat wall thickness of 103 teats were evaluated from 622 measurements before and directly after milking and every 15 minutes until 1 hour after milking (6 measurements). The most significant differences in internal proportions were determined within those values measured before and immediately after milking. The dynamics of changes in the length of the teat canal demonstrated the extension by 27%. A sudden restoration of the initial length by 11% was detected one hour after milking. Differences in teat canal diameter were significant at P<0.01 between the 1st and 4th measurement. The initial extension was 17% immediately after milking and the restoration about 9% one hour after milking. The wall thickness was strengthened during the 2nd measurement immediately after milking in comparison with the 1st measurement before milking (P<0.01). Significant differences in the wall thickness were detected between the 1st and 2nd measurement (+26%; P<0.01) and between the 2nd and 3rd measurement. The ultrasonographic scanning of the teat parameters was a useful tool to study teat changes caused by milking.

Key words: ultrasonography, teat canal, milking traits, udder

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The quantity and quality of produced milk as well as the efficiency of its production is directly dependent on good health of cows and in particular cow's udder. Preparation of the mammary gland, milking, technology of milking and care of the udder are a set of technical operations which significantly affects not only the quality and quantity of milk, but also the economics of a herd. Although it has improved milk production hygiene, the introduction of mechanized milking and new technologies became the cause of many failures and changes in efferent teats duct (Twardoń et al., 2001). The morphological characteristics of the mammary gland are important for both milk production and machine milking. The teat of farm animals used for milk production is an important part of the udder, onto which a milking cluster is attached and which serves the role of both a valve regulating the outflow of milk and of a natural barrier for exogenous infections (Hamann and Mein, 1988). So far, studies on the reaction of the teat to mechanical milking have been conducted mainly using traditional research methods describing the health state of the teat (Geishauser and Querengässer, 2000). There is a general agreement that machine milking can result in congestion and oedema of the teat tissue, especially at the teat end, and also influences teat diameter, penetrability of the teat canal, and defense mechanisms. The functional effect of impaired teat fluid circulation may be divided into, firstly, effects concerning teat canal closure and passage of pathogens, and secondly, possible effects on the immunological defense mechanisms concerning antigenic detection and initiation of immunological responses (Paulrud et al., 2005).

Milking technique is the most important environmental influence on the teat (Hamann and Mein, 1988). Proper milking machine function is necessary to maintain the integrity of the teat canal tissue. Milking machine defects and faulty milking management may explain 16–45% of the inter-herd variation in mammary gland health. The udder health is affected by a number of interrelated components such as presence and pathogenicity of microorganisms, environment and management, cow factors such as conformation and immunological performance, and treatment and prevention strategies. The number of these components may be steered through genetically based processes (Emanuelson et al., 1988). The teat and the teat canal allow the flow of milk from the udder to the outside, but should prevent the entrance of microorganisms. Factors that have been associated with the quality of this defense are udder depth, fore udder attachment, teat length, teat shape, and milkability. It is likely that high udders, with a good attachment and small teats are less prone to teat lesions, and therefore to a mechanical lesion to the teat canal (Schukken et al., 1997).

Many authors also demonstrated relationships between milking routine (stimulation time, forestripping, pre-dipping, post-dipping), milking machine and udder health, in terms of somatic cell count (SCC) and teat tissue integrity (Zecconi et al., 1992; Tančin et al., 2006). The internal structure of the mammary gland can be studied by means of ultrasonography (Strzetelski et al., 2004). Studies using ultrasound equipment in teat diagnostics have been carried out for only a few years now and they generally focus on the development of a methodology in order to obtain an image of intramammary structures (Franz et al., 2001; Strzetelski et al., 2005; Nishimura et al., 2011). Udder and teat scanning is generally performed for diagnosis of milk flow disturbances but also is increasingly used for examination and measurement of different anatomical structures (Neijenhuis et al., 2001; Klein et al., 2005; Fasulkov, 2012; Szencziová and Strapák, 2012). Suitable quality of pictures especially for the examination of anatomical structures could be obtained with use of frequency from 7.5 MHz to 13 MHz. The aim of the present study was to measure different parameters of the teat and teat canal and to assess morphological changes in teats of cows, occurring as a reaction to mechanical milking with the help of ultrasonographic scanning. Furthermore, the relationships between milk flow traits, milk SCC and teat changes were investigated. The hypothesis was then tested whether characteristics of the teat considerably influenced the milking characteristics or the udder health status.

Material and methods

A total of 26 dairy cows of the Holstein breed in the first (n = 13) and second lactation (n = 13) were included in the data set. The experiment was carried out on experimental farm Ruda – Lány of the Czech University of Life Sciences in Prague, the Czech Republic. All the cows had clinically healthy udders. The differences in the internal parameters of the teat were evaluated. The scanning procedure was based on studies of Stádnik et al. (2010) and Ślósarz et al. (2010). Ultrasound images of the longitudinal cross-section of teats from an Aloka SSD500 (Aloka Co., Ltd., Tokyo, Japan) scanner coupled with 7.5 MHz linear probe (UST512U-7.5 MHZ) were taken on animals six times a day at regular time intervals: before evening milking, just after evening milking and 4 times at 15-minute time intervals (15, 30, 45 and 60 minutes) after evening milking. The ultrasound probe was placed in a plastic cup filled with warm water (36±1°C), into which teats were immersed. Exploration depth was 7 cm. Images were recorded in real time on a computer and archived in the form of video files. Later, these files were transformed into images (jpeg2). The diameter and length of teat canals and the thickness of teat walls were measured on images recorded in NIS 3.2 software (Laboratory Imaging s.r.o., Prague, Czech Republic). Teat canal length was measured in millimeters as the distance between the distal and proximal end (from the outer end to the inner end, with accuracy of 0.1 cm). The length of the teat canal was recorded three consecutive times (triplicate scans of the same teat) and the mean of the measurements was used. Teat wall thickness was measured in millimeters 10 millimeters over Furstenberg's rosette. The experiment was carried out on 103 teats with a total of 622 teat measurements taken. Somatic cell count, milk flow and daily milk yield were measured during the entire observation as well. The cows were housed in a free stable with straw bedding and milked twice a day. All measurements were taken during the evening milking, where the first two measurements were made in the milking parlour, and the other four in restraining cages. A sample of milk was taken from each cow for milk SCS. Because of the intensive nature of the measurements only 3 cows per milking could be scanned. In the milking parlour during the evening milking, teat scans of all teats were made directly after routine pre-milking treatment (t0) and directly after removal of the milking cluster (t1). Then the cows were moved to the restraining cages and repeatable scans of the same teats were taken at 15-minute intervals (t2–t5) until an hour after milking. Measurements of three different properties of the internal structure of the teats (teat canal length, teat canal diameter and teat wall thickness) were taken by one person (Figure 1).

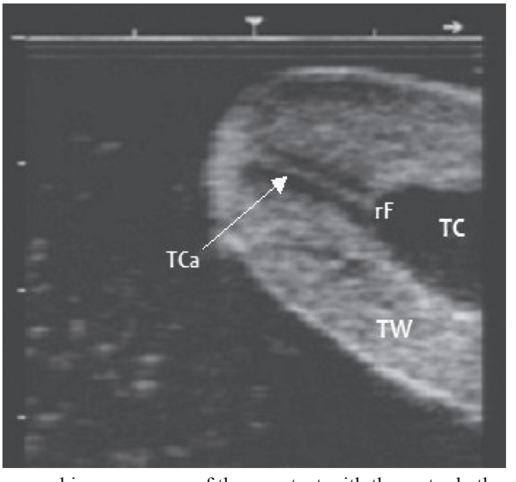

Figure 1. Ultrasonographic appearance of the cow teat with the water bath method (vertical scan, 7.5 MHz linear probe): TCa – teat canal; TW – teat wall; TC – teat cistern; rF – Furstenberg's rosette. Photo: own data

Scans of the same teats (t0–t5) were used to analyse the teat internal structure changes after milking and their influence on milking characteristic and somatic cells. Daily and total milk yield (kg), average milk flow (kg min^{-1}) and maximum milk flow (kg min^{-1}) were evaluated as the traits of milk performance. All of the measured traits were recorded with the help of milking software used on experimental farm Ruda – Lány. Evaluation of SCC was performed by fluoro-opto-electronic method in the State Veterinary Institute, Prague, the Czech Republic. The somatic cell count values were converted to a somatic cell score (SCS) by the following equation:

$$LS = log2\ (Somatic\ cell\ count/100) + 3$$

Statistical analyses

All the teat scans were used to calculate the mean value and standard error by using the statistical program SAS STAT 9.1 (SAS Institute, 2001). Animals were divided into three groups according to the mean values (< x – 0.5 sd; x – 0.5 sd to x + 0.5 sd ; > x + 0.5 sd), different in each measured time (Table 1). In the first group measured before milking (t0) the range of inclusion was (>10.014), which represented 41 teat measurements (n = 41). The second group was between values (10.014–11.448) with 28 measurements (n = 28) and the third group was (<11.448) with 34 evaluated teats. The groups measured immediately after milking (t1) were in the range of values (>12.405; 12.405–13.866; <13.866) with (n = 34 for the 1st group; n=36 for the 2nd group; n = 33 for the 3rd group) measurements. Fifteen minutes after milking (t2) were the groups in the range of values (>11.958; 11.958–13.306; <13.306) with (n = 37; n = 35; n = 31) measurements. After thirteen minutes (t3) it was (>11.436; 11.436–12.804; <12.804) with (n = 35; n = 34; n = 34) teat measurements. After forty five minutes (t4) it was (>10.991; 10.991–12.337; <12.337) with (n = 33; n = 41; n = 29) and one hour (t5) after milking, the measured mean values for groups were (>10.436, 10.436–11.826, <11.826) with (n = 30; n = 44; n = 29) evaluated teats (Table 2). The effect of time interval between measurements (t0–t5) and lactation rank (1,2) on teat morphology (Table 1) was estimated by the analysis of variance using GLM procedure with the help of statistical program SAS 9.1.

Table 1. The internal proportions of teats and their changes depending on time of measurement and lactation ranks

Factor Measurements	n	Teat canal length	Teat canal diameter	Teat wall thickness
		LSM±SE	LSM±SE	LSM±SE
Before milking (t0)	26	10.731±1.43 AC	0.667±0.04 A	6.092±0.94 A
Immediately after milking (t1)	26	13.137±1.46 Ba	0.787±0.04	8.561±0.84 BC
15 min after milking (t2)	26	12.632±1.34 Db	0.756±0.04	8.133±0.72 D
30 min after milking (t3)	26	12.12±1.36	0.728±0.04 B	7.671±0.64
45 min after milking (t4)	26	11.664±1.34	0.702±0.04	7.275±0.64
1 hour after milking (t5)	26	11.131±1.39	0.695±0.03	6.849±0.69
Lactation				
1	13	11.84±0.17 a	0.724±0.05	7.68±0.08
2	13	12.54±0.20 b	0.736±0.06	7.70±0.10

Different letters denote significant differences between groups at a, b – P<0.05 and A, B, C, D – P<0.01.

The data set was analysed using a generalized linear model (SAS 9.1). The following equations were used:

$$Y_{ijk} = \mu + RANK_i + TIME_j + e_{ijk}$$

where:

Y_{ijk} – observed value of the dependent variable (teat canal length, teat canal diameter, teat wall thickness),

μ = average value of the dependent variable,

$RANK_i$ = fixed effect of the ith lactation rank,

$TIME_j$ = fixed effect of the jth time interval between measurements,

e_{ijk} = residual effects.

Table 2. The effect of the observed milking characteristics and SCS on teat canal length

Factor Measurements	Teat canal length														
	daily milk yield LSM±SE			milk yield per milking LSM±SE			average milk flow LSM±SE			maximum milk flow LSM±SE			SCC LSM±SE		
	group 1	group 2	group 3	group 1	group 2	group 3	group 1	group 2	group 3	group 1	group 2	group 3	group 1	group 2	group 3
Before milking (t0)	30.52± 1.080	29.99± 1.288	30.57± 1.162	13.59± 0.643	14.32± 0.767	13.68± 0.692	2.66± 0.127	2.83± 0.152	2.81± 0.137	4.29± 0.204	4.43± 0.243	4.32± 0.219	5.59± 0.107 a	5.90± 0.128	5.93± 0.116 b
Immediately after milking (t1)	28.55± 1.156 a	32.98± 1.086 b	29.423± 1.133 a	13.19± 0.709	14.80± 0.666	13.39± 0.695	2.53± 0.140	2.88± 0.132	2.87± 0.138	3.97± 0.221 a	4.69± 0.208 b	4.32± 0.217	5.73± 0.119	5.59± 0.112 a	6.04± 0.117 b
15 min after milking (t2)	28.87± 1.104 a	32.68± 1.117 b	29.62± 1.180	13.32± 0.677	14.30± 0.685	13.867± 0.724	2.54± 0.132 a	2.92± 0.134 b	2.85± 0.141	3.98± 0.208 a	4.76± 0.212 b	4.29± 0.222	5.64± 0.115	5.79± 0.116	5.95± 0.123
30 min after milking (t3)	29.38± 1.133	32.49± 1.170	29.47± 1.142	13.48± 0.690	14.24± 0.712	13.76± 0.695	2.57± 0.134 a	2.99± 0.139 b	2.79± 0.135	4.05± 0.214 a	4.73± 0.221 b	4.27± 0.215	5.61± 0.116	5.82± 0.120	5.93± 0.117
45 min after milking (t4)	30.19± 1.189	31.62± 1.077	29.06± 1.263	13.69± 0.715	14.24± 0.648	13.41± 0.760	2.58± 0.140	2.92± 0.127	2.76± 0.149	4.18± 0.224	4.62± 0.203	4.15± 0.238	5.54± 0.119 a	5.80± 0.107	6.02± 0.126 b
1 hour after milking (t5)	30.61± 1.268	30.31± 1.029	30.32± 1.260	13.78 ±0.756	13.66± 0.614	14.08± 0.752	2.58± 0.147	2.95± 0.119	2.67± 0.146	4.19 0.232	4.68± 0.188 a	3.98± 0.231 b	5.54± 0.126 a	5.89± 0.102 b	5.87± 0.126

Different letters denote significant differences between groups at a, b – $P<0.05$.

$$Y_{ijk} = \mu + RANK_i + TEAT_j + e_{ijk}$$

where:

Y_{ijk} – observed value of the dependent variable (daily milk yield, milk yield per milking, average milk flow, maximum milk flow, SCC),

μ – average value of the dependent variable,

$RANK_i$ – fixed effect of the ith lactation rank,

$TEAT_j$ – fixed effect of the jth group according to teat length during individual times of observations,

e_{ijk} – residual effects.

The differences between the estimated variables were tested at the levels of significance P<0.05 and P<0.01.

Results

The internal proportions of teats (teat canal length, teat canal diameter, teat wall thickness) and their changes depending on time of measurement and lactation ranks are presented in Table 1. Recovery of the teat after milking is very clearly demonstrated due to intensive measurements. All of the evaluated traits showed significant differences in time comparison.

The average length of the teat canal measured via ultrasound was 10.73 mm before milking, 13.13 mm immediately after milking, and the recovery of the teat tissue one hour after milking was 11.13 mm. The teat diameter was 0.66 mm before milking and 0.78 after milking, and at the last measurement (one hour after milking) it averaged 0.69 mm. Teat wall thickness shows the same tendency: from 6.09 mm before milking, 8.51 mm after milking, and 6.84 mm one hour after milking. The most significant differences in internal proportions were determined within those values measured before and immediately after milking. The differences in the teat canal length were significant at P<0.01 between the 1st, 2nd and 3rd measurement and at P<0.05 between the 2nd and 3rd measurement, while these differences were significant at P<0.01 and P<0.05 in comparison with the other measured traits. The dynamics of changes in the length of the teat canal demonstrated extension by 27%. A sudden restoration of the initial length by 11% was detected one hour after milking, however, the teat canal did not reach the initial length during our examination (1 hour after milking + 16%). The differences in teat canal diameter were significant at P<0.01 between the 1st and 4th measurement. The initial extension was 17% immediately after milking and restoration was about 9% one hour after milking. The wall thickness was strengthened during the 2nd measurement immediately after milking in comparison with the 1st measurement before milking (P<0.01). Significant differences in the wall thickness were detected between the 1st and 2nd measurement (+26%; P<0.01) and between the 2nd and 3rd measurement. One hour after milking the wall remained 8% thicker than before milking. In the present study, 1st and 2nd lactation cows were observed and non-significant differences between these lactations were detected except for the teat canal length. Higher values of all internal proportions were measured in the 2nd lactation but a significant difference was only confirmed for teat canal length ($P<0.05$).

The effect of the observed milking characteristics (daily and total milk yield, average milk flow, maximum milk flow) and SCS on the teat canal length is presented in Table 2. A statistically significant difference was found among groups 1, 2 and 3 between milking traits and time of measurements. Statistically significant differences ($P<0.05$) were found among groups 1, 2 and 3 in daily milk yield and between groups 1 and 2 for maximum milk flow immediately after milking (t1). Also statistically significant differences ($P<0.05$) between groups 1 and 2 were found for daily milk yield, average milk yield and maximum milk flow 15 minutes after milking (t2). At the fourth measurement, 30 minutes after milking (t3) significant differences were detected between groups 1 and 2 for average milk flow and between groups 1 and 2 for maximum milk flow. The last significant difference was found one hour after milking (t5) between groups 2 and 3 for maximum milk flow. The average values for milk somatic cell score showed statistically significant differences ($P<0.05$) between groups 1 and 3 before milking (t0); between groups 2 and 3 immediately after milking (t1); between groups 1 and 3 forty-five minutes after milking (t4); and between groups 1 and 2 one hour after milking (t5).

Discussion

In cows, it has been suggested that teat traits with a high hereditary status should be taken into account in selection studies, in order to reduce mastitis prevalence (Hamann and Burvenich, 1994). Moreover, there is strong correlation between teat status and udder health. Because of this relatively high hereditary trait of the teat and its effect on udder health, numerous studies concentrate on its internal structure. Many authors who have reported on teat ultrasonography in cows found it to be the best solution for teat research because of its noninvasiveness and the fact that it is relatively simple, effective and safe to both the subject and the operator (Franz et al., 2001; Klein et al., 2005). Our experience during the experiment was that the scanning equipment was relatively easy to use. This makes the ultrasound scanning technique a good tool to study the teat. It can be also used, for instance, to evaluate the effects of different milking techniques, liners, and milking machine settings for the reaction of the teat. In most literature, recovery time of teats is interpreted as the time that it takes for the teats to decrease the penetrability of the teat canal to endotoxin or teat canal diameter after milking (Schultze and Bright, 1983). In our study the recovery of the teat tissue did not reach the initial length during one hour of examination, which is in accordance with Neijenhuis et al. (2001) who reported that full recovery of the teat may take between 3 and 8 hours. The teat canal, as one of the most important elements of the defense mechanism against the pathogens is the first barrier to intramammary infections. The development of the disease depends on the pathogens passing defense line and entering the teat canal. Because of that it is advised to keep cows standing for 1 or 2 hours after they have been milked. When teats have an increased penetrability, they should not be in contact with any possible infection sources, such as bedding material of cubicles (Neijenhuis et al., 2001). As in other studies in this field, the teat canal penetrability cannot be measured directly by ultrasonography. However, it is assumed that teat canal changes reflect teat canal penetrability. Therefore, parameters that estimate the changes in teat tissue are the best available parameters to estimate the teat canal penetrability under practical circumstances. In this study, the teat canal length showed the highest relative changes after milking with measured average value of 10.73 mm before milking and 13.13 mm after milking (elongation of 27%), which is in accordance with the findings of Neijenhuis et al. (2001), who found elongation of teat canal after milking to be about 19–28%. Teat canal length in Holstein cows before milking was reported to be 12.1 mm by Gleeson and O'Callaghan (2002) and from 3 mm to 18 mm by Paulrud et al. (2005). One hour after milking teat canal length averaged 11.13 mm, which shows that the teat canal did not reach the initial length. Studies with the use of ultrasound equipment for the diagnostics of teats in the Hungarian population of Simmental cattle were carried out by Húth et al. (2001), who found the increasing values of somatic cell counts in the milk of the cows with the longer than average length of the teat canal. A similar dependence was observed by Franz et al. (2003) in sheep of four different breeds kept in Austria. In a study conducted on goat milk diagnosed using ultrasonography before and 1 h after milking Fahr et al. (2001) found a thickening of the teat walls amounting up to 30% and a lengthening of the teat canal by approx. 20%. Ślósarz et al. (2010) reported similar results in goats, however, morphological changes, particularly teat swelling, were retained 10 hours after milking, between 8–11% in relation to their initial condition. Thickening of the teat wall in examined goats, despite the passage of time, was thus greater than that considered natural for properly performed machine milking in cattle (Hamann et al., 1994). In a similar study with sheep (Wójtowski et al., 2006) morphological changes in teats under the influence of milking were less intensive and disappeared before the passage of 10 hours after milking. However, the greatest, highly significant differences in their size were recorded 4 hours after milking. The performed analyses indicate a slightly different course of teat regeneration in goats and sheep after milking in comparison to dairy cattle. In goats and sheep, the elongation of teat canals after milking was less intensive and lasted shorter than the thickening of the teat wall. In contrast, in cattle, the length of the teat canal returned to the condition before milking after 5 hours, while the thickening of the teat wall lasted only approximately 1 hour (Gleeson and O'Callaghan, 2002). In our study we focus on relatively shorter time measurements (after 15 min.) to detect the detailed teat structure changes and their possible effect on milking traits and udder health. By these measurements, the teat canal length had a significant effect on milk flow characteristics such as daily milk yield, average milk flow and maximum milk flow and somatic cell score, at different measurement times. The length and morphological structures of teat canal may have an effect on the development of udder infections. A close relationship was recorded between the predisposition to mastitis and too short or too long teat canals (Seyfried, 1992). Seyfried (1992) stated that especially long as well as short teat canals enhance bacterial colonization of the udder; on the other hand, Klein et al. (2005) recommend long and narrow teat to improve udder health. Also many authors repeatedly reported that the teat canal length had a significant effect on the flow of milk through teat canal, which may be easy or difficult (Biederman and Hubal, 1994). However, the damage of the teat canal may be a cause for milk flow disorders. Loppnow (1959) reported that the teat canals were longer in hard milking cows in comparison to easy milking cows and also that the teat canal length has an effect on milking time since in cows with a longer teat canal milking time was significantly longer. In the present study, when the milk yield and length of the teat canal (TC) were compared, cows that had the longest TC (group 3) showed the least milk yield. Although the animals in group 2 had slightly longer TCs than cows in group 1, they produced a higher amount of milk. Also in milk flow, the cows with longer TC (group 3) had longer milking time than cows with shorter canals. According to Michel (1986) the optimal length of teat canal is between 8 and 12 mm in cows and longer teat canals could negatively affect the milking. These findings were confirmed by Celik et al. (2008), who found teat canal length in Holstein cows to average 11.51 mm, but differed from those reported by Geishauser and Querengässer (2000), who found teat canals in various breeds to be 8 mm long (shorter than in our study) and by Klein et al. (2005), who found them to be 15.7 mm long in Brown Swiss cows (longer than in our study). These differences can be caused by breed differences, lactation stages and lactation numbers. Seyfried (1992) confirmed a significant difference between Brown Swiss and Holstein cows in teat canal length and Klein et al. (2005) reported that lactation numbers had an effect on teat canal length. Hamann and Burvenich (1994) detected that lactation number affected the measurements of the udder and teat canal, and when lactation numbers increased, the teat canal length increased as well.

The authors suggested that these changes in teat canal length are due to the exposure of the teat to mechanical effect of the milking machine. In the present study we have found a significant difference between lactations, when the older animals had statistically longer teat canals in the second lactation, and non-significant but increased values in teat diameter and wall thickness were found. The teat canal diameter showed small changes during the lactation, with a slight increase. According to Hamann and Mein (1988) mechanical exposure of a teat during machine milking could cause teat diameter to increase with advancing lactations. Significant differences can be found after the 3rd or 4th lactation (Hamann and Burvenich, 1994). The teat canal diameter was not significantly different from the value before milking (0.667 mm) and 1 hour after milking (0.695 mm), but it was statistically significant at $P<0.01$ between the 1st (before milking) and 4th measurement (45 min after milking). No significant differences between teat diameter, milking traits and SCS were found. Similar results were obtained by Hamann et al. (1994) but additionally, they found significant differences in teat diameter between healthy and infected udder quarters. A slight increase in the teat wall thickness was observed during lactation. The mean values for wall thickness were 6.092 mm before milking and 6.849 mm an hour after milking, which is consistent with Neijenhuis et al. (2001) who found an increasing tendency for wall thickness, from 6.8 mm before to 8.3 mm an hour after milking. The same authors also reported that the full recovery of the teat wall could be more than 6 hours. In this study no significant differences between teat wall thickness, milking traits and SCS were found; on the other hand, Klein et al. (2005) found significantly thicker teat walls in Austrian Simmental compared to Brown Swiss cows.

In conclusion, ultrasonography was used as an easily applicable, modern and noninvasive method, allowing the visualization of the teat and its morphological changes. Numerous studies have been published using ultrasonography as an effective measuring technique for udder and teats. In this study milking traits were evaluated depending on the time of measurement and internal parameters of the teats. Maximum deviations for the teat internal parameters were found immediately after milking. The highest relative changes after milking were found for the teat canal length, where statistically significant differences between milk flow, lactation and somatic cell score were found. It was demonstrated that the length of the teat canal was affected by animal age (lactation), but on the other hand teat canal length had an effect on the milking traits (milk flow, milk yield). Teat wall thickness and teat diameter had an increasing tendency over lactation, but no significant differences were observed. Further investigations are needed to gain more knowledge about the interactions among a cow, an udder, a teat and milking techniques.

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Związek między morfologią wymienia i strzyków a cechami doju i zdrowotnością wymienia w badaniach USG krów mlecznych

STRESZCZENIE

Celem badań było zwrócenie uwagi na możliwość użycia ultrasonografii jako przydatnego narzędzia w ocenie cech morfologicznych wymienia i strzyków u krów mlecznych, w odniesieniu do cech doju i zdrowotności wymienia. Dwadzieścia sześć krów mlecznych rasy holsztyńskiej, w pierwszej i drugiej laktacji (n = 13), badano za pomocą USG, przy użyciu głowicy liniowej. Powrót parametrów strzyków do poziomu sprzed udoju określano za pomocą skanowania wiązką ultrasonograficzną. Długość i średnicę kanału strzykowego oraz grubość ścian strzyka oceniano na 103 strzykach, podczas 633 pomiarów przeprowadzonych przed udojem, bezpośrednio po udoju oraz do 60 minut po udoju, w odstępach 15-minutowych (6 pomiarów). Najbardziej istotne różnice w wewnętrznych proporcjach określono w obrębie wartości mierzonych przed i bezpośrednio po udoju. W dynamice zmian długości kanału strzykowego stwierdzono wydłużenie o 27%. Nagły powrót do 11% początkowej długości zaobserwowano godzinę po udoju. Różnice w średnicy kanału strzykowego były istotne na poziomie $P<0,01$, pomiędzy 1. a 4. pomiarem. Powiększenie wyniosło 17% bezpośrednio po udoju i około 9% w godzinę po udoju. Grubość ściany kanału strzykowego uległa zwiększeniu podczas 2. pomiaru zaraz po udoju, w porównaniu do 1. pomiaru przed dojem ($P<0,01$). Istotne różnice w grubości ściany wykryto między 1. a 2. pomiarem (+26%; $P<0,01$) oraz między 2. a 3. pomiarem. Badanie USG parametrów strzyków okazało się przydatne w określaniu zmian zachodzących w strzykach na skutek doju.