DEPENDENCIES OF ELASTICITY CHANGES AND GEOMETRIC PARAMETERS ON TENSION FORCE OF LINERS USED FOR MILKING

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Summary. Investigated was the effect of liner tension force in teat cups on geometric parameters and elasticity of cow teats. Increased hardness (declined elasticity) of teats after milking was registered for all measurement variants of liners tension force in teat cups. The biggest differences of elasticity occurred at milking with liners with tension force 80 N, whereas the lowest in variants with liner tension force in teat cups 30 N.

Key words: mechanical milking, liner, teat parameters

Introduction

It is hard to overestimate the negative impact of mechanical milking on dairy cow teats, which often results in congestion, teat-end trauma but also leads to accumulation of lymph and swelling which decreases the lumen of the teat canal prolonging the milking process and too long effect of the underpressure and liner on the udder. It generates changes of teats condition [Hańckowiak et al. 2006; Szlachta et al. 2001]. Therefore, it is crucial to construct the liners which would most minimize this negative effect [Jugowar and Winnicki 2007; Krzyś et al. 2010; Olechnowicz 2007].

Aim of research

The aims of research were: understanding the teat elasticity changes before and immediately after milking, determining geometric parameters of teats (the length and diameters – at the end and at the base of a teat), analysis of dependencies of measured values on liner tension.

Object of research and methods

The investigations were conducted at the "Swojec" Agricultural Experimental Unit on a group of 25 first lactation cows and on a group of 45 older cows.

A cutometer – device for elasticity measurement was used for measuring teat elasticity. The research involved pressing a teat with a determined force and measuring the hollow (teat deflection). The tension force was determined on the level of 23 N. The plate area was 400mm^2 (square plates with equal 20mm long sides). The measurements were conducted before and after milking, and a proper order of measurements was maintained: the diameter at the base of teat was read, then its length, sequentially for: FL (front left), FR (front right), RL (rear left) and RR (rear right).

Obtained results were subjected to an analysis using Statistica programme and MS Excel calculation sheet. The results were analysed in the following arrangements: for first-calf heifers; for cows during their second or later lactation; globally for the whole herd.

Research tasks (detailed objectives) were realized bidirectionally:

– teat elasticity was measured before and immediately after milking,
– geometric parameters of teats (lengths and diameters – on the end at the base of a teat) were measured.

The term: teat elasticity was used while discussing the research results. By teat elasticity is meant teat property which involves susceptibility to deformation in result of pressure force (generated by means of research instrument).

A change of teat elasticity after milking in relation to its elasticity prior to milking is a result of outer influences on the teat during milking. In this case the outer effects comprise the following factors:

– effect of underpressure in the teat chamber of teat cup causing the teat sucking into the liner and movement of body fluids (blood and lymph) towards the teat end,
– effect of liner on the teat (teat massage),
– teat loading with the milking machine weight.

The following parameters were measured and analysed during testing of teat geometric parameters: teat length before and after milking, teat diameter on about 1 cm from its end, teat diameter by the udder (about 1 cm from the teat base).

The measurements were conducted using a digital camera – photographs were taken of individual teats with a milimeter scale placed beside each of them (Fig. 1). This method is faster than the traditional measurement of the lengths and diameters of teats (no necessity to register individual measurements) and less stressing for the animals (no need to touch the teats). The cow number was ascribed to each photograph and a teat was identified (FL, FR, RL, RR). The photographs of the individual teats were taken in a regular order to avoid mistakes. Following the photographs import to the computer, they were opened in Adobe Photoshop application and teat parameters were measured using Ruler Tool. By means of Ruler Tool a measuring section with the length equal to the teat length was plotted from the toolbar on the photograph and then transferred to the photo fragment showing the scale, and finally the length was read.

The analogous activities were carried out while measuring teat diameters, however in this case it was necessary to turn the section by 90^o, which required the use of information box to make sure that the length of the section did not change.

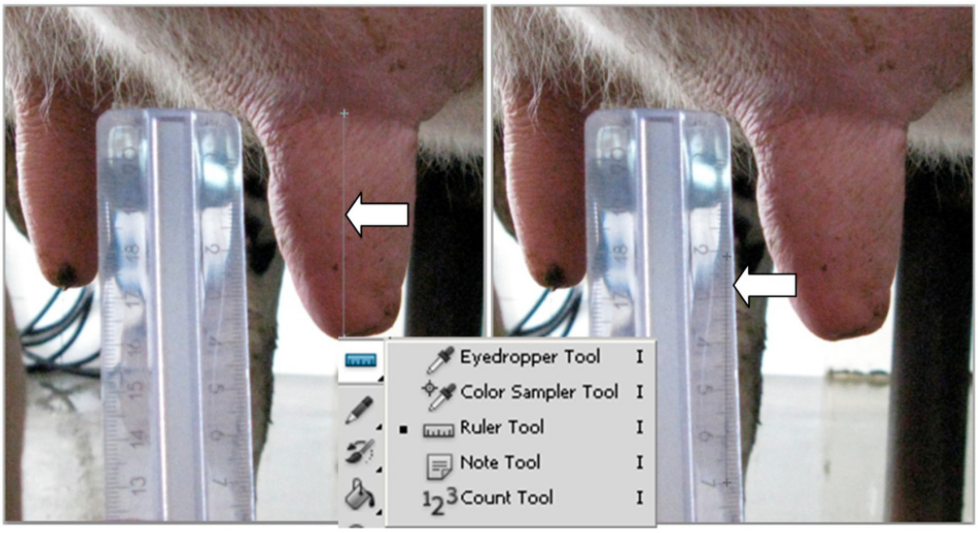


Fig. 1. Measurements of teat length using a camera and Photoshop application

Research results – teat elasticity

In all measurement variants of liner tension force in teat cups, an increase in hardness (a decline in elasticity) of teats was registered after milking.

The biggest differences of elasticity were noted at milking with liner of tension force 80 N and the lowest in variants when liner tension was 30 N. Figure 2 presents the function showing the impact of liner tension on a percent increase in a teat hardness (decline in its elasticity). The values were presented separately for the first-calf heifers, cows in subsequent lactations and globally for the whole herd. The highest decreases in elasticity were registered for measurement variant with liner tension force-80 N, which reached even 29% for the cows in subsequent lactations and were slightly lower for cows during first lactation. Definitely lower decrease in elasticity were registered for the variants with tension force 30 N (respectively 5.1 and 2.9%).

Dependencies describing the courses shown in Figure 2:

– for first lactation cows: $dTw = 0.00003 \cdot F^2 + 0.015 \cdot F - 0,04$
– for subsequent lactations: $dTw = 0.0004 \cdot F^2 + 0.0003 \cdot F + 0.005$
– average for the whole herd: $0.0004 \cdot F^2 + 0.0004 \cdot F – 0.004$

Table 1 and Figure 3 present a comparison of differences in teat elasticity between individual tension forces, i.e. how much teat elasticity is higher at tension force 30 N in relation to the force 50 N and for the other arrangements , i.e. 30 N in relation to 80 N and 50 N to 80 N.

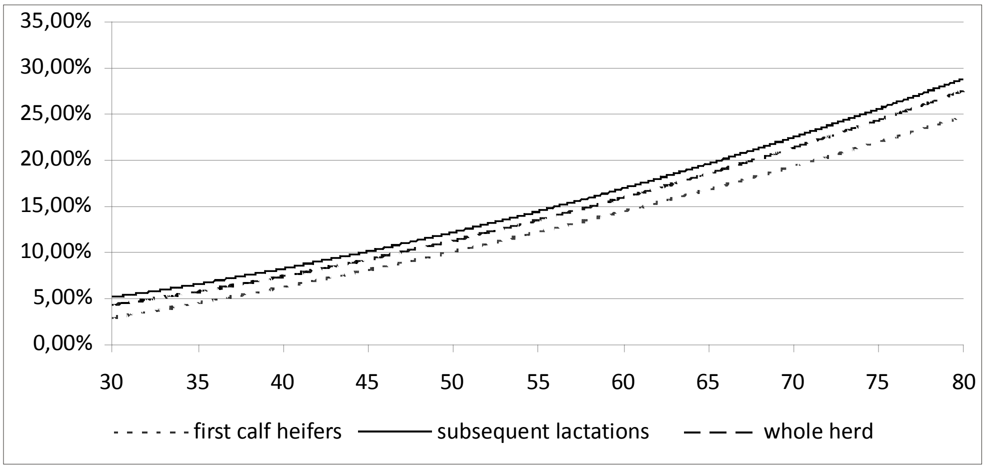


Fig. 2. Dependence of percent increase in teat hardness dTw (decline in elasticity) on liner tension F. Average for first lactation cows, fur subsequent lactations and for the whole herd

Table 1. Differences in teat elasticity at individual milking variants for individual cow groups

	30 N vs. 50 N	30 N vs. 80 N	50 N vs. 80 N
First-calf heifers	7.20%	21.90%	14.70%
Older cows	7.10%	23.80%	16.70%
Whole herd	7.00%	23.30%	16.30%

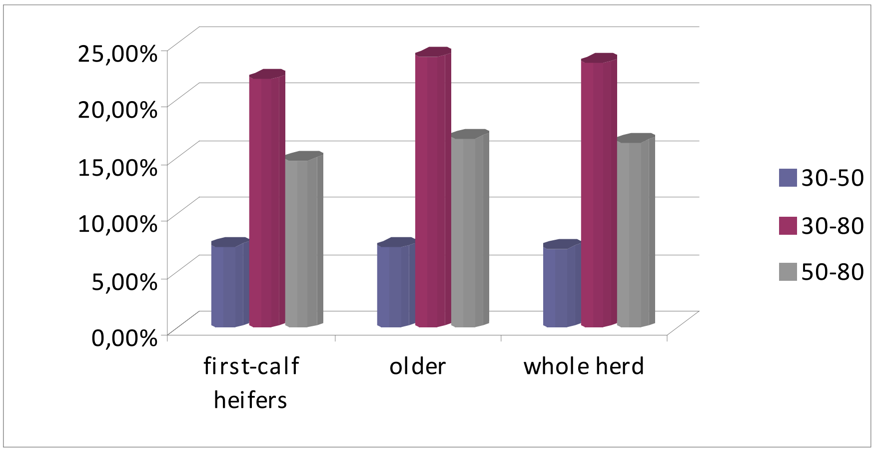


Fig. 3. Percent difference in teat elasticity at individual milking variants for individual cow groups

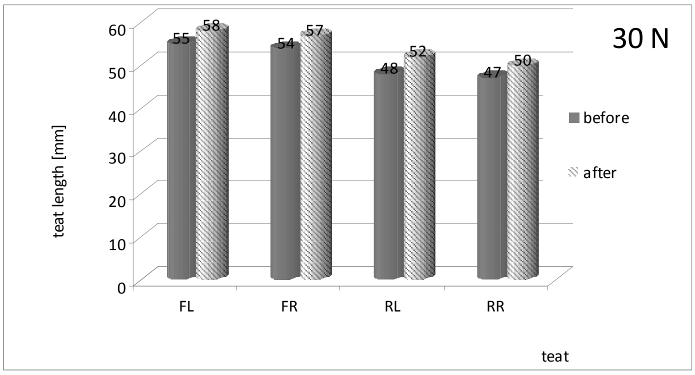
Research results – Teat geometric parameters

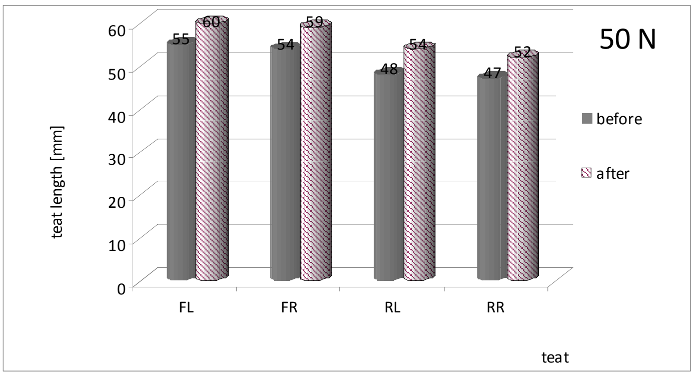
Underpressure forces and forces resulting from the massage affect a teat during mechanical milking. Geometric parameters of teats (the length and diameters) change. A comparative analysis of these parameters before and after milking allows to determine the intensity of the above mentioned forces impact on a teat and therefore these parameters may provide one of the standards of intensity of milking machine effect on teats.

A significant effect (in each case on the significance level 0.5) of liner tension on a change of teat length and teat end diameters was registered at milking by standard variants at various liner tension force. Only the impact of liner tension on a change of teat diameter by the udder remained beyond the significance level limit.

At this stage of investigations considerable differences were observed for individual cows, which resulted from the animal ontogenetic features, however the analysis presented below (based on average values for the whole herd) is appropriate in case of each animal, irrespective of lactation period.

Figure 4 presents the differences of teat length before and immediately after milking. It may be noticed that independently of the measurement variant, increase in its length was registered for each teat after milking. The highest increases were registered at liner tension 80 N. The lowest values occurred for tension forces 30 N. Measured values ranged from 3 to 4 mm (for 30 N), from 5 to 6 mm (for 50 N) and from 7 to 9 mm (for 80 N).





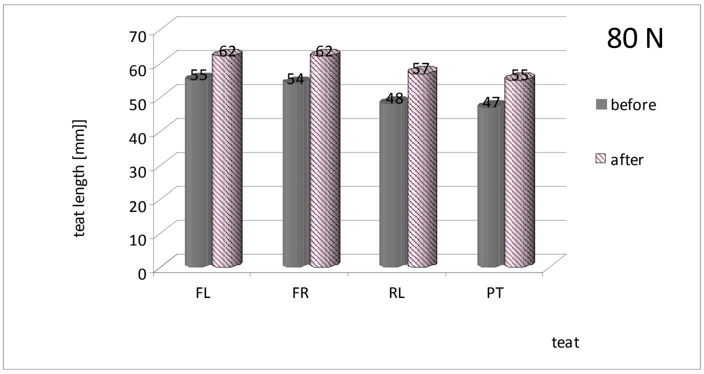


Fig. 4. Differences in the length of teats before and after milking for individual measurement variants (liner tension 30, 50 and 80 N). Teats: front left (FL), front right (FR), rear left (RL), rear right (RR). Average for the whole herd

The differences in teat lengths at variable tension forces were, depending on teats, from 4 to 5 mm (between 30 and 50 N), from 2 to 3 mm (between 50 and 80 N) and from 4 to 5 mm (between 30 and 80 N) – Fig. 5. It constituted from 10% to over 17% of the initial teat length.

Similar results were obtained for the analysis of liner tension on the teat end diameters (Fig. 6). Differences between the measurements before and after milking were a maximum of 1 mm. Despite a relatively small difference, statistical analysis allows for a simultaneous stating the significance of the liner tension on teat diameter (significance level α=0.05). The greatest changes of teat diameters were caused by milking with the use of liners of 80 N tension force and the smallest – 30 N. The differences of teat ends prior to and after milking were presented in Figure 7.

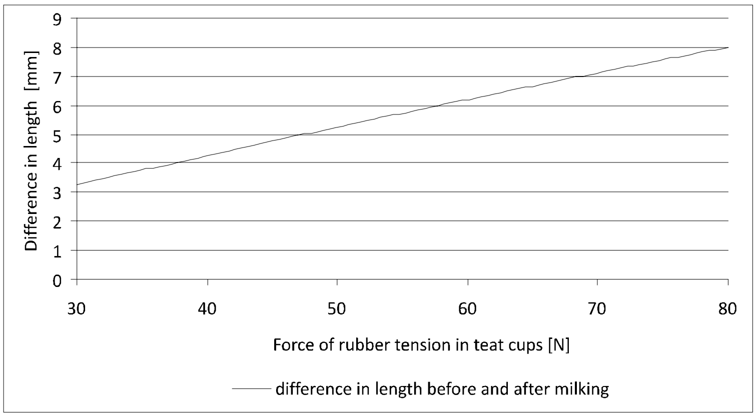


Fig. 5. Average difference of teat length dL before and after milking (X axis – liner tension in cups [N]; Y axis – difference of teat length [mm]) in tension force function F. Function describing the course of : $dL = -0.0002 \cdot F^2 + 0.1133 \cdot F$

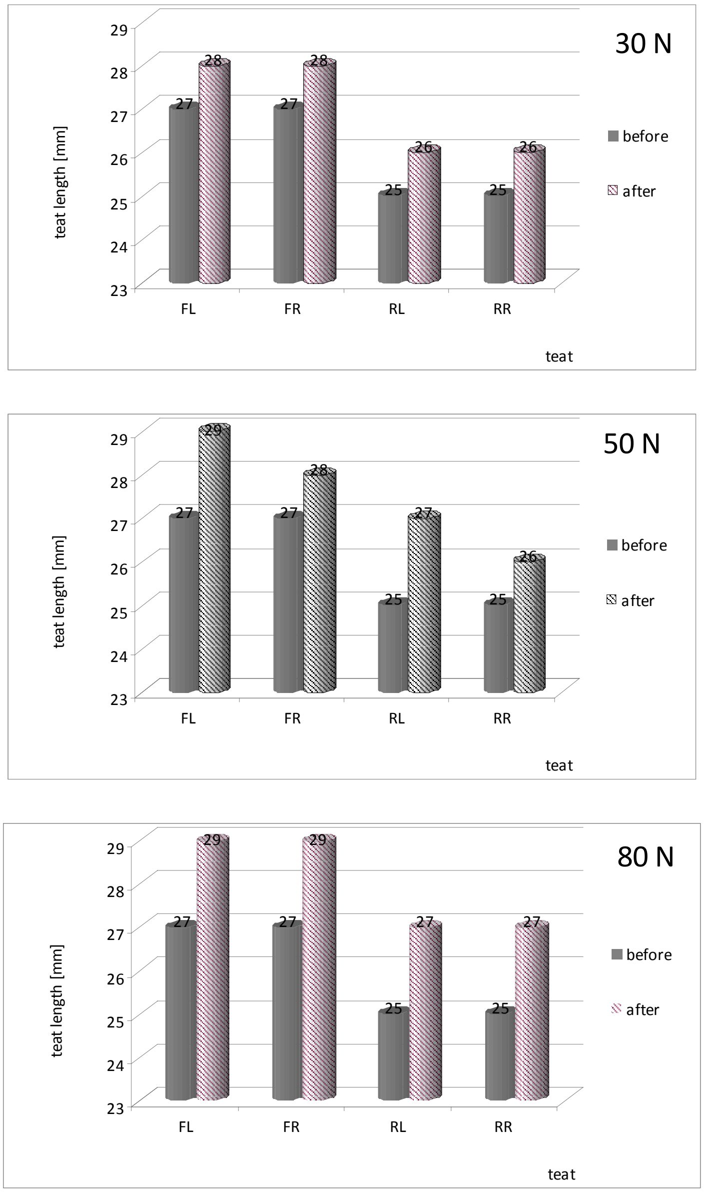


Fig. 6. Differences between teat-end diameters before and after milking for individual measurement variants (forces of liner tension in a teat cup 30, 50 and 80 N). Teats: front left (FL), front right (FR), rear left (RL), rear right (RR). Average for the whole herd

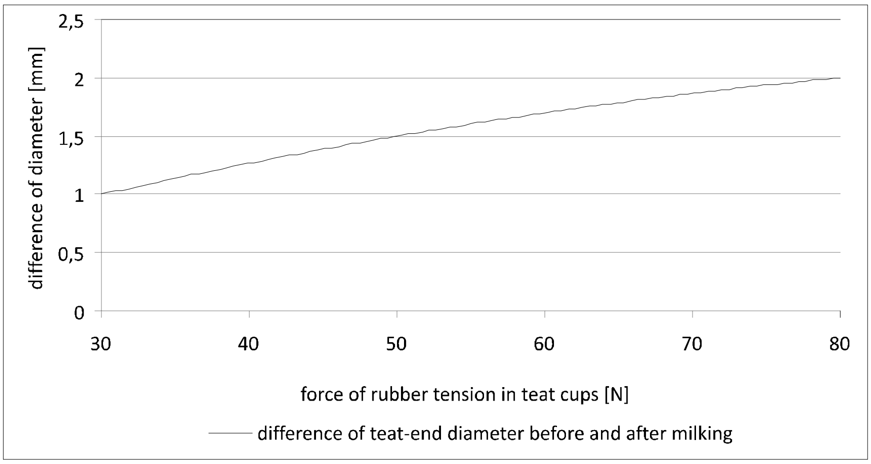
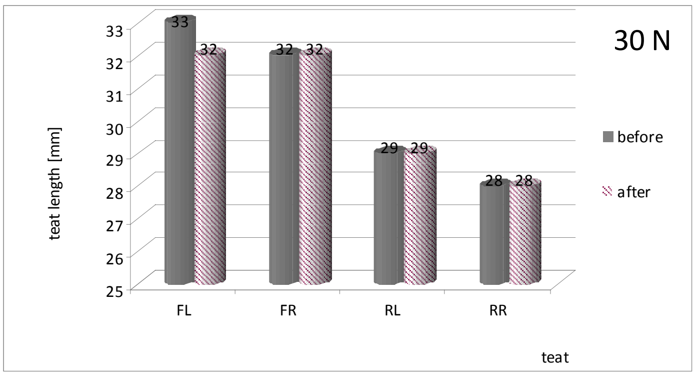


Fig. 7. Average difference of teat-end diameters sSk before and after milking (X axis – force of liner tension in a teat cup [N]; Y axis – differences in diameters [mm]) in function of tension force F.
Function describing the course of dSk =-0.0002·F^2 + 0.0383·F

In case of differences in teat diameters measured at their base (Fig. 8 and 9), a decrease in this parameter value was registered after milking. In this case a considerable impact of animal ontogenic features was observed – for some cows this parameter value was slightly increasing, whereas for others it was decreasing, and in some cases was different for individual teats. No impact of milking on this parameter values can be stated.

Statistical calculations do not allow either to state any influence of liner tension on shaping the value of teat diameters at the base (significance level α=0.2804). Similar results were obtained for first-calf heifers (α=0.2610) and for higher lactations cows (α=0.3181).



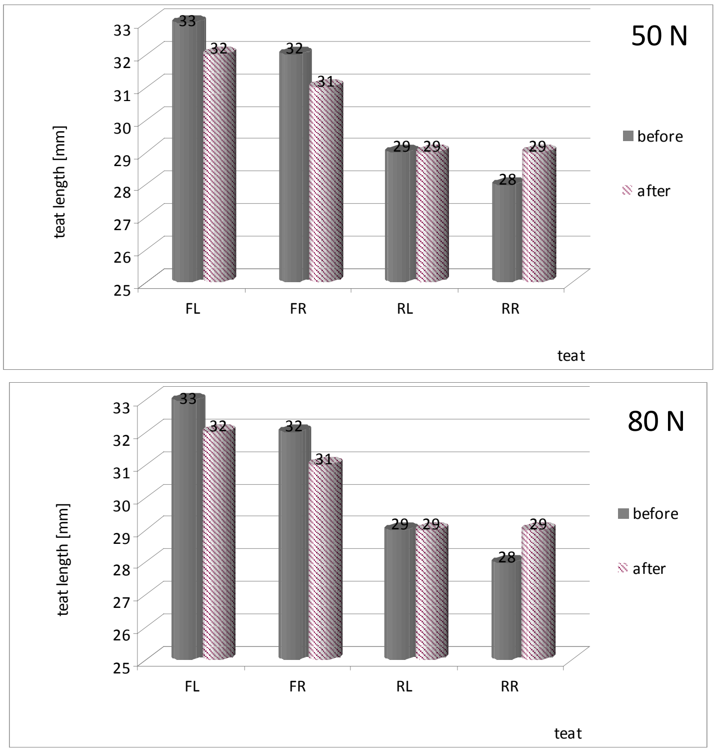


Fig. 8. Differences in teat diameters at the base before and after milking for individual measurement variants (forces of liner tension in a teat cup 30, 50 and 80 N).
Teats: front left (FL), front right (FR), rear left (RL), rear right (RR). Average for the whole herd

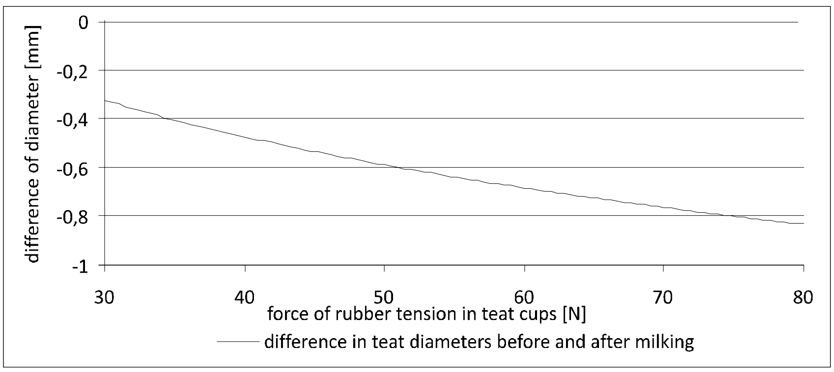


Fig. 9. Average difference of teat diameters at the base dSn before and after milking (X axis – forces of liner tension in a teat cup [N]; Y axis – difference of diameters [mm]) in liner tension F.
Function describing the course of $dSn = -0.517 \ln(F) + 1.4304$

Conclusions

Analysis of the research results allowed to draw the following conclusions:

1. Increase in hardness (decline in elasticity)of teats after milking was registered at all measurement variants of liner tension.
2. The greatest difference in elasticity occur when milking using liners with tension force of 80 N, the smallest at the liner tension force of 30 N. The difference reached even about 24%.
3. A considerable dependence was registered (in each case on the significance level 0.0000) between the changes of teat length and teat-end diameters and forces of liner tension in teat cups.
4. No statistically significant differences were stated during the analysis between teat diameters at the base and liner tension.

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ZALEŻNOŚCI ZMIAN ELASTYCZNOŚCI I PARAMETRÓW GEOMETRYCZNYCH STRZYKÓW OD SIŁ NACIĄGU GUM STRZYKOWYCH UŻYTYCH DO DOJU

Streszczenie. Zbadano wpływ siły naciągu gum strzykowych w kubkach udojowych na parametry geometryczne oraz na elastyczność strzyków krów. Dla wszystkich wariantów pomiarowych sił naciągu gum w kubkach udojowych rejestrowano wzrost twardości (spadek elastyczności) strzyków po doju. Największe różnice elastyczności występowały przy doju gumami o sile naciągu równej 80 N, najniższe zaś - w wariantach o sile naciągu gum w kubkach równej 30 N.

Słowa kluczowe: dój mechaniczny, guma strzykowa, parametry strzyków

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