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# Investigation of basic teat morphological structures in cows by different pulsation parameters

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## Abstract

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An ultrasound study of the basic morphological structures of the teats in lactating cows was performed. The experiments were carried out in different technological conditions of machine milking. The changes in the length and diameter of the teat canal, the teat wall thickness, the teat diameter in the region of Furstenberg's rosette, the diameter of teat cistern in its middle part and the cistern diameter at the teat base at a different pulsation rate of the milking units are followed. The influence of the type of milking liners on the morphological structures mentioned is analyzed. Summarized results of ultrasound studies of the basic teat morphostructures highlight the functional advantage of tri-circle milking cups with triangular milking liners. The marked advantage is guaranteed in a pulsation rate of 60-65 $min^{-1}$.

*Keywords:* udder morphology; teat health; triangular; milking liner; pulsation rate

## Introduction

The udder as the main organ related to milk production is the main subject of study in cattle from milk breeds. As well as a prerequisite for higher productivity its functional and morphological qualities are subject to continuous research on machine milking (Hamann & Mein, 1996; Forsback et al., 2005; Schukken et al., 2006; Haeussermann et al., 2011).

Damage to the teats from the milking machine is the main cause of milk disorders. The emphasis in recent scientific studies is entirely focused on the state of the tip teat due to its interaction with the milking units (Hamann & Mein, 1996; Forsback et al., 2005; Schukken et al., 2006; Haeussermann et al., 2011). Efforts of scientists, designers and milking producers ultimately led to the creation of milking units with a different form of milking liners and milking cups (Hillerton et al. 2000; Schukken et al., 2006; Haeussermann et al., 2011).

In the new type of milking units the pulsation chamber configuration is of a more complex shape (known as the "tri-circle") and it is presented as the "safest" to the tip teats health of the mammary gland. Numerous studies have been found to have a contradictory character but it may well be the opinion that truly milking units with a three-segment configuration of the pulsation chamber other than the cylindrical shape provide milder and more supple milking (Hillerton et al., 2000; O'Callaghan, 2001; Forsback et al., 2005; Schukken et al., 2006).

A number of authors use the echographic scanning method to study the changes occurring in the teat tissues of the milking cows (Rogers & Spencer, 1991; Kunc et al., 2000; Klein et al., 2005; Szencziova & Strapak, 2012). Their results indicate that echography can be used to determine the effect of different types of milking units and pulsation adjustments on the teat tissue changes (morphological structures). In this connection the aim of the present study namely ultrasound examination of the basic morphological structures of the teats in cows under different milking conditions was set.

## Materials and Methods

The subject of this paper is the main morphological structures of teat before and after milking. Their changes have been made according to the milking regime by ultrasonography.

Experimental animals include 12 clinically healthy cows grown under the same conditions. In the first month of the experiment cows were milked with a conventional milking units at a pulsation rate of 60 $min^{-1}$ and a ratio $\gamma = 60/40\%$. Within the second month of the experiment the cows were milked with a modified (three-segment configuration) milking units with frequency regimes $f = 60\ min^{-1}$, $f = 70\ min^{-1}$ and $f = 80\ min^{-1}$ ($\gamma = const = 60/40\%$).

As indicators (Fig. 1) for assessing of the teat condition before and after milking the dimensions of the following morphological structures are taken: the length and diameter of the teat canal, the teat wall thickness, the teat diameter in the region of Furstenberg's rosette, the diameter of teat cistern in its middle part and the cistern diameter at the teat base.

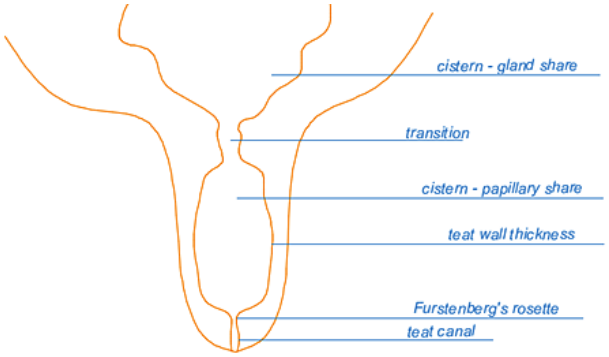


**Fig. 1. Basic morphological structures of the teat**

Ultrasonography (Fig. 2) was performed using a SonoScape A5 Vet apparatus and a linear multi-frequency transducer. The scanning is done by means of a "direct contact" technique at a vertical position of the transducer and a frequency of 12.0 MHz. When applying the transducer to the papillary epidermis an ultrasound gel (Eco-Ultra gel, Milano, Italy) was used to make better contact.

The teat canal is visualized as a hyperechoic structure. The transition between the teat canal and the teat cistern, referred to as Furstenberg's rosette, is hypoechoic. Three layers of the teat wall were clearly distinguished – outer hyperechoic (skin), hypoechoic (musculature) and inner hyperechoic (mucosa). The lumen of the teat cistern

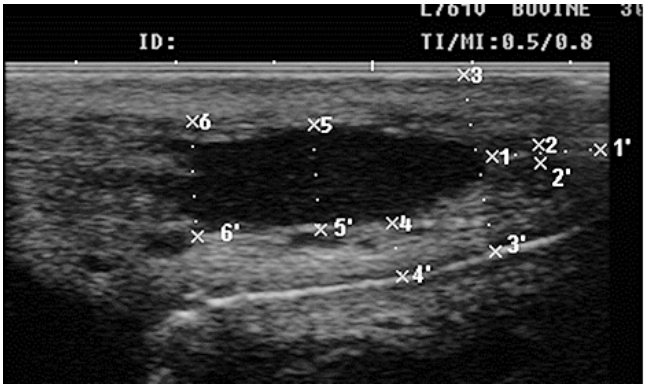


**Fig. 2. Ultrasonography measurements of the structures in the milk papilla**

*Legend*: from 1 to 1′ is the teat canal length; from 2 to 2′ – the teat canal diameter; from 3 to 3′ – the teat diameter in the region of Furstenberg's rosette; from 4 to 4′ – the teat wall thickness; from 5 to 5′ – the teat cistern diameter in its middle part; from 6 to 6′ – the teat cistern diameter at teat base.

was anechoic when it was full of milk. At the boundary between teat and gland cisterns, anechoic blood vessels from the venous ring of Furstenberg could be observed.

Measurements of morphostructures were performed before milking, immediately after milking, at the first and second hours after milking.

## Results and Discussion

The analysis of the results obtained is based on the mean values of the studied morphological structures under the conditions of experimental milking regimes. The influence of the type of milking units and its frequency parameters on the change of the ultrasound dimensions of the teat structures is interpreted graphically. The established dependencies are illustrated in Fig. 3.

From the graphs in Fig. 3 it is evident that the average value of the teat length canal before milking is 8.5 mm. Immediately after milking with a conventional milking device, it decreases to 6.7 mm. In subsequent minutes (after milking), the teat length canal begins to recover to the baseline with slight fluctuations between the first and the second hour.

The change in the teat length canal after milking with a modified milking units is analogous to the above. The only difference is the gradual recovery of the investigated parameter within the experimental observation time.

The change in frequency of the pulsation system, both in the conventional and the modified milking units, impacts poorly on the teat canal length. Despite the insig-

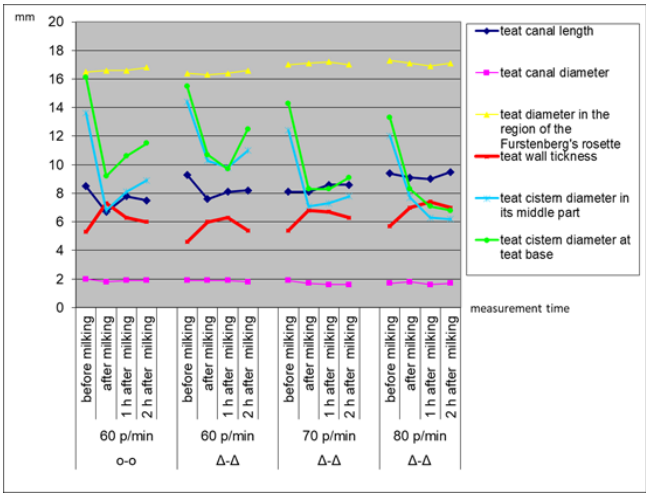


**Fig. 3. Graph of the values (in mm) of the measured teat parameters by ultrasonography when working with two types of milking units and different frequency regimes**

*Note*: The symbol „o-o" is a reference to a conventional milking unit with a circular shell and a circular milking liner, and the symbol „Δ-Δ" is a reference to a modified milking unit with a tri-circle shell and a triangular milking liners.

nificant differences in the observed values, it is noticeable that when working with a modified milking units and a pulsation rate f = 80 min$^{-1}$ to the second hour the teat length canal is completely restored. The summary of these dependencies leads to the conclusion that the smallest changes in the teat length canal are detected using a modified units and the pulsation rate f = 80 min$^{-1}$.

Mechanical effects during machine milking cause thickening of the teat wall thickness. The established dependence is most pronounced when milking with a conventional milking units and amounts to almost 2 mm from the original measurement. Immediately after milking the teat wall thickness is approximately 7.5 mm.

Machine milking with a modified milking units has a lesser impact on the teat wall thickness. In the pulsation rate 60 min$^{-1}$ the maximum of the teat wall thickness is about 6.2 mm, which is close to 20% less compared to the same value recorded using the conventional unit.

The influence of the frequency regime on the teat wall thickness has a positive correlation. The vertical disposition of the corresponding graphs highlights that the increased pulsation rate leads to thickening of the teat wall. This is a real argument in support of the hypothesis that unjustifiably high pulsation rates (over 60-65 min$^{-1}$) disturb peripheral blood circulation, causing partial hemostasis and lymphostasis.

The milking unit type as well as the rate of the pulsation system have a very small effect on the teat canal diameter and the diameter of the teat in the Furstenberg's rosette region. These morphological structures remain with almost constant dimensions, regardless of milking conditions and milking regimen.

During the machine milking period the teat cistern diameter at the teat base sharply decreases. This reduces the total throughput of the dairy tract and implies an extension of the total milking time. This dependence is less pronounced when milking with a modified unit which is an indirect argument for its advantage over conventional.

The increased operating pulsation rate above 60 min$^{-1}$ results in a noticeable reduction in the teat cistern diameter at the teat base (the registered difference is over 2 mm). This is an objective justification for the thesis that pulsation ratees above 60-65 min$^{-1}$ act «stressively» on smooth muscles in the structure and create prerequisites for disruption of dairy production.

The milking process reduces the teat cistern diameter in its middle part. This dependence is one-way in all experimental variants and is a consequence of the elasticity dynamics in the teat wall when milk is removed from the udder. In this sense the results of this dimension are not indicative of the overall impact of the milking unit on the functional status of the teat.

## Conclusions

The machine milking of cows leads to prolongation of the teat length canal. Dependency is more pronounced in milking units complete with conventional membranes (milking liners). Mechanical effects during machine milking cause thickening of the teat wall most likely by partial hemostasis and lymphostasis. Thickening of the teat wall at the end of machine milking is nearly 20% lower when working with modified milking units. Increasing the pulsation rate in time of machine milking causes a noticeable thickening of the teat wall. Perhaps unreasonably increased pulsation rate leads to problems (disturbance) of peripheral blood circulation. Machine milking reduces the teat cistern diameter at teat base, thereby altering the milking throughput. The effect is increased in high pulsation rate. The reduction of the this morphological structure is significantly weaker when working with modified milking units. Summarized results of ultrasound studies of the basic teat morphological structures highlight the functional advantage of tri-circle milking cups. The marked advantage is guaranteed in a pulsation mode of 60-65 min$^{-1}$.

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