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Study on the effect of the teat reaction on the time components of the pulsogram in various types of milking liners

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Abstract: The relationship between the milking process phases and the artificial teat reaction have been studied. Milking units with a conventional and tri-circle shape of the pulsation chamber were used. The conclusions are related to the reaction of the teat support and the changes of the time components in the pulsogram. The filling of the milking chamber with an artificial teat reduces the absolute duration of the transitional phases "a" and "c" and prolongs the actual phases "b" and "d" in all the experimental rates.

Keywords: milking device; artificial teat; pulsation parameters

One of the main directions in the development of the milking equipment is the improvement in milking units and the refinement of their functional parameters. This is a new technological wave, providing comfortable and quick milking with minimised stress effects from the milking machine (Banev 2001). The use of electronic pulsation systems makes it possible to adjust the pulsation rate, the ratio and the pulse structure with great precision over a wide range. This makes it possible to search for combinations among the parameters of the pulsation system which correspond to the maximum in the physiology of the milk production.

The international ISO standard, section 5707:2007 is the only system that regulates the minimum relative values of the individual time components of the impulse without reference to a specific rate range and ratio. The duration of the actual milking phase "b" is required to be over 30% of the "T" impulse period without any additional regulation in terms of its absolute duration.

Some of the leading milking equipment manufacturers (such as Milkrite|InterPuls) offer users time component recommendations for the pulsogram, which do not comply with ISO 5707:2007 to some extent. The Milkrite|InterPuls company methodology lists the minimum and maximum permissible absolute values for the actual "b" phase (as well as for the "d" massage phase) without indications and recommendations as to its relative duration with regard to the impulse period.

The tests and studies show that the milking liner has to be fully open for 500–600 ms of the time of one pulsation and be closed at least 15% of the total time of the cycle (period), but not less than 150 ms. The presumption is to provide enough time for the massage and restoration of the peripheral teat circulation (Osteras et al. 1995) ISO 5707:2007.

Experimentally, Worstorff and Bilgery (2002) prove that infections increase when decreasing the duration of the contraction of the milking liner. If the milking liner is closed one-third of the period, the occurrence of new mastitis infections is reduced.

This statement is also supported by the authors Osteras et al. (1995). They firmly demonstrate that, in terms of udder health, it is best when the true massage phase "d" is at least 330 ms. The duration

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of the latter under 250 ms significantly increases the Somatic Cell Count (SCC).

Practical experience and research have shown that the precise structuring of the pulsation parameters is necessary to maintain good udder health and reduce the speed of the mechanical milking (O'Callaghan 1996; Peychev 2001; Peychev et al. 2004; Ipema et al. 2005).

In scientific literature there are no methodological instructions for the specific conditions and method of setting up pulsation systems.

In this sense, the question arises if the pulsation system setup is performed in a laboratory (purely technically), will the parameters remain unchanged in the milking mode?

The objective of the present paper is to perform a comparative study of the repeatability of pulsation parameters of a cow milking unit refined for a free volume of the milking chamber and in the presence of an internal support (artificial teat).

MATERIAL AND METHOD

Milking units complete with milking liners with a round and triangular cross-sectional shape are the object of the study.

The time characteristics of the pulsogram for all the studied variants included in the experiment are the focus of the study.

The experiments have been carried out under laboratory conditions (Figure 1) on a pipeline milking machine, equipped with milking units with electronic pulsators, with an option for setting up the pulsation rate mode and the ratio. To determine the effect of the teat support on the time components of the pulsogram, an artificial polymeric teat was used. The values of the pulsation parameters have been recorded within two different circumstances:

(*i*) with the free volume of the milking chamber of the experimental milking cup (*ii*) with an artificial teat placed in the milking chamber volume.

The experiments have been carried out within the frequency range of 60, 90 and 120 min^{-1} at a vacuum rate of 50 kPa and a ratio of 50 : 50%. The data recording was undertaken by a standardised pulse analyser of the Alfa Laval company model PT IV (Sweden).

The processing and interpretation of the experimental data conforms to the overall graphic profile of a pulsogram by the ISO 5707:2007 standard, shown in Figure 2.

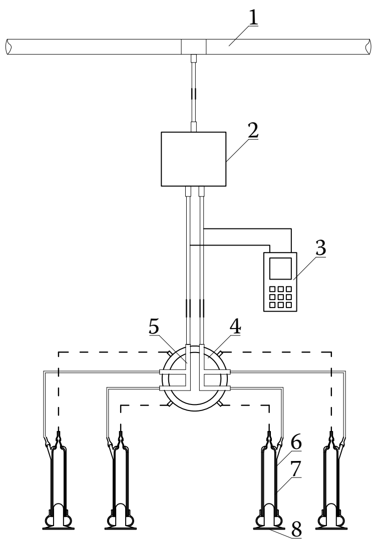

Figure 1. A general view of the experimental setup

1 – vacuum pipeline; 2 – pulsator; 3 – pulse analyser; 4 – collector; 5 – pulse distributor; 6 – shell; 7 – milking liner; 8 – support (artificial teat)

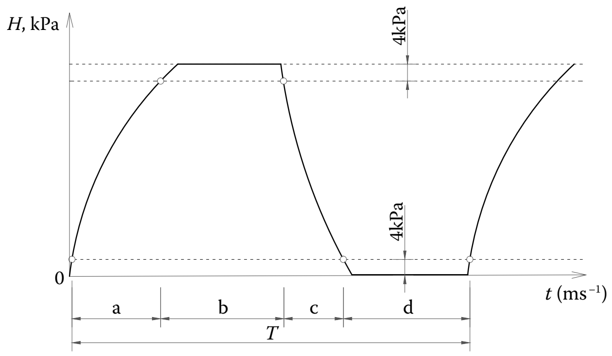

Figure 2. The overall graphical profile of the pulsogram by the ISO 5707:2007 standard

a – the duration of the transitional process from the atmospheric pressure to the nominal vacuum in the volume of the milking cup pulsation chamber (front of the pulsogram); b – the duration of the "true milking" phase (vacuum mode within the pulsation chamber volume); c – the duration of the transitional process from the nominal vacuum to the atmospheric pressure in the volume of the pulsation chamber (back of the pulsogram); d – the duration of the "true massage" phase (the atmospheric pressure within the volume of the pulsation chamber); *H* – the pressure

RESULTS AND DISCUSSION

The effect of the pulsation rate on the phases of the pulsogram has a similar trend in all the experimental gradations, regardless of the type of milking liner and the measurement conditions (with or without an artificial teat) (Figure 3). Each specific

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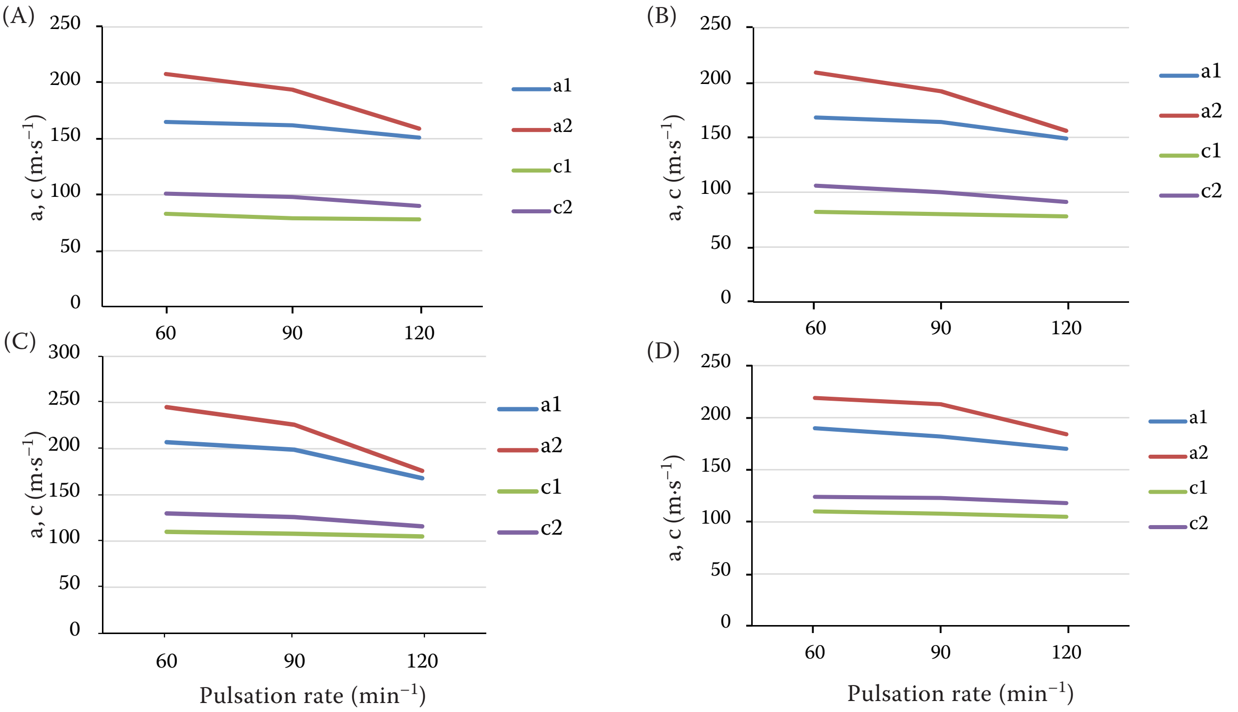

Figure 3. The absolute duration of the transitional phases ("a" and "c") of the pulsogram of the studied milking units with and without the internal support of an artificial teat.

(A) triangular rubber liner barrel with no mouthpiece air jet (B) triangular rubber liner barrel with a mouthpiece air jet (C) round rubber liner barrel (D) round silicon liner barrel; a, c – transitional phases; 1 – denotes the transitional processes of the milking units with an artificial teat support; 2 – with no support of an artificial teat support

value for a given experimental variant is obtained as an arithmetic mean of fifteen measurements.

An increase in the frequency within the experimental regimes results in some shortening of phase "a". The specific reduction depends on the type of milking liner and is within the range of 11–13% for the artificial teat measurements (Figure 3). These findings concur with Worstorff and Bilgery (2002). They found that the shortening of phase "a" is significantly influenced by the length of the teats. In animals with longer teat lengths, the reduction effect of this transient period is more pronounced.

In the absence of an "internal support", the tendency of the relative decrease in the vacuuming time of the pulsation chamber (phase "a") is even more pronounced and amounts to 15–25%.

The analysis of the values obtained hereto emphasises that the increased pulsation rate reflects on the shortening of the transitional phase "a" regardless of the type of milking liner and the measurement conditions. In practical terms, the effect of the established reduction may have a negative impact on the so-called "slipping" of the milking cups and cause difficulty in extracting the milk after the third minute of milking. Such conclusions are reached by the authors Spencer and Rogers (1991).

The effect of the pulsation rate mode and the presence of an "internal support" in the milking cups is similar to the devacuumising phase of the pulsation chambers (the transitional phase "c"). The period of the latter is reduced by increasing the rate within the experimental levels. The trend is similar for the four types of milking liner. In the measurements with an artificial teat, its duration is reduced within the range of 4–6%, whereas the shortening of the phase is more pronounced and is within the range of 5–10% with a free milking chamber.

The uncontrolled reduction of the time structure "c" (the devacuumising phase of the pulsation chamber) dramatically increases the differential pressure between the milking and the pulsation chamber of the respective milking cup (Peychev, Banev 2001). The walls of the milking membrane (the milking liner) contract impulsively, their maximum deformation being immediately around and below the tip of the milking papilla. From a hypothetical point of view, such an effect could provoke parakeratosis at the teat tip. This hypothesis is also supported by the authors Kochman et al. (2008). They prove that

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the unjustified shortening of the "c" phase leads to an increase in the pressure on the teat. This is accompanied by discomfort for the animals during machine milking. The same authors warn that an uncontrolled increase in the "c" phase by more than 120 ms is a negative effect because it violates the ratio between the times "c" and "d" (within one cycle) and extends the total time of the machine milking.

The technical design (the presence of a mouthpiece air jet) and the material of the milking liner do not reliably affect the duration of the two transitional processes (phases "a" and "c"). This finding is somewhat in contradiction to the hypotheses raised by Reinemann (2019). According to the author, the material and the presence of a vent in the milking liner significantly affects its dynamics during milking. In our experiments, we found no such dependencies.

The summary results of the dynamics of the transitional "a" and "c" phases emphasise that their variability in the measurement mainly depends on the pulsation rate mode and the presence of a support in the milking chamber of the milking cup.

The change in the pulsation rate within the experimental levels has a very strong effect on the duration of the actual milking phase (phase "b") over one period (Figure 4). The dependence has a similar expression for all the types of milking liners and reduces the duration of phase "b" by an average of 74%.

The observed trend regarding the influence of the pulsation rate is exactly the same in the actual massage phase (phase "d"). An increase in this argument reduces the absolute time for the massaging of the teats which creates the risk of chemostasis and lymphostasis causing the painful oedema to the teats. This hypothesis is in line with the results of the studies by Reinemann (2019) and Upton et al. (2016). The authors cited (independently of one another) that they are adamant that reducing the absolute duration of phase "d" below 150 ms leads to an oedema to the teats with all its consequences.

The observed dependence on the effect of the pulsation rate on phase "b" is similar for the actual massage phase (phase "d"). The analysis of the graphs describing phases "b" and "d" (Figure 4) highlights a point of "refraction" (inflection) after which the function changes its nature. Within the performed experiments, the inflection point coincided with a rate of 90 min^{-1}.

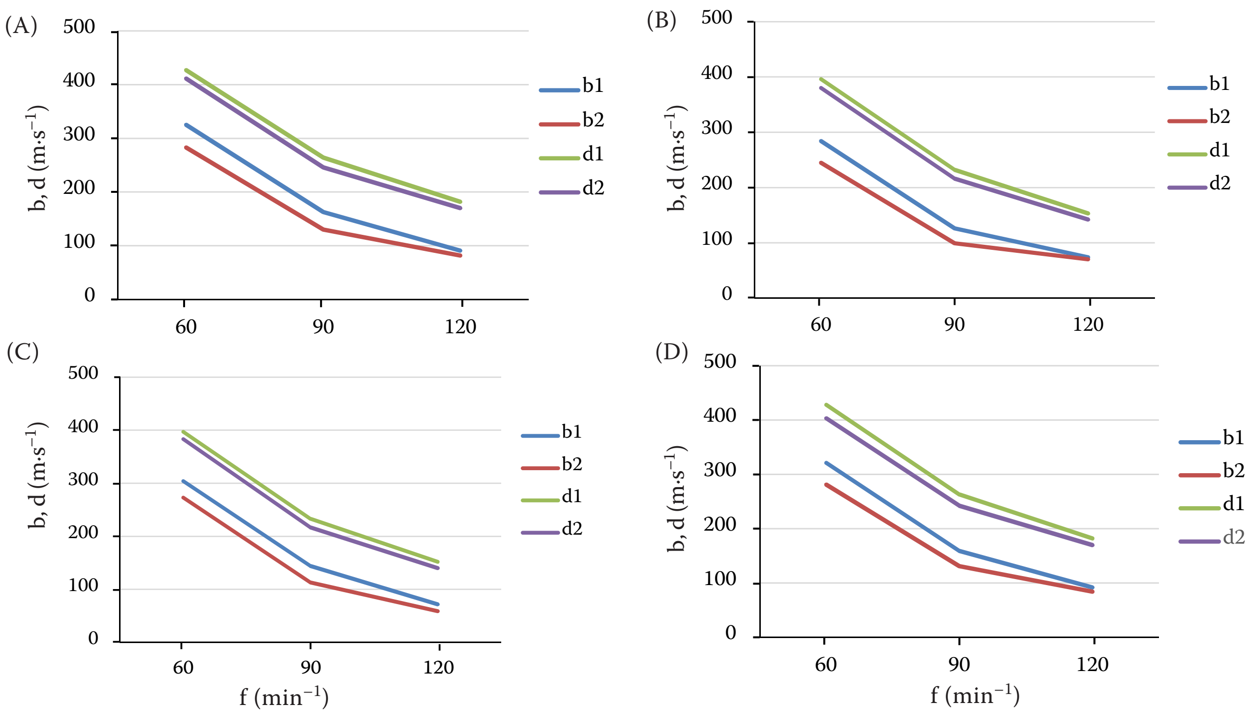

Figure 4. The absolute duration of the actual phases ("b"and "d"of the pulsogram of the studied milking units with and without the internal support of an artificial teat

(A) triangular rubber liner barrel with no mouthpiece air jet (B) triangular rubber liner barrel with a mouthpiece air jet (C) ound rubber liner barrel (D) round silicon liner barrel; b, c – transitional phases; 1 – denotes the actual phases of the milking units with an artificial teat support; 2 – with no support of an artificial teat

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The above results unambiguously imply that an unwarranted pulsation rate increase (especially at levels above 90 min^{-1}) drastically reduces the absolute time for milk sucking within one pulse. On a practical level, this will inevitably have an effect on extending the machine milking time and questions the efficient milking of the animals (Peychev 2001).

The vertical disposition of the graphical representations of phases "b" from Figure 4, as well as the comparison of the experimental data, show that the presence of an artificial teat in the milking chambers of the milking cups prolongs phase "b" by an average of 12% compared to the free milking chamber volume measurements. The established finding is of purely practical importance as the unjustified increase in the actual milking (phase "b") over certain values carries certain risks. This is evident in the results of Reinemann's (2019) research. It underlines the need to balance between the duration of phase "b" and the level of the vacuum to reduce the likelihood of an oedema to the teats.

The change in the actual phase "d", depending on the measurement conditions, is also similar. The presence of an internal support in the milking chamber results in an increase in the duration of the actual massage phase by an average of 6% (compared to the measurement with the free volume of the milk chamber) for all experimental variants.

The results obtained from the experiments highlight the need for a uniform methodological standard for a particular pulsation rate and way of recording the pulsograms, which is currently lacking as an imperative both in theory and in practice of machine milking. Which of the values for the duration of phases "b" and "d" should be considered "representative" is a question without a definite answer. The conclusions made by Reinemann (2019) are in a similar vein. The author recommends establishing a balance between the factors of the duration of the actual "b" phase and the vacuum mode of the milking machine. However, another question arises: can this balance be universal for all dairy breeds, for all herds or should it be refined for each object?

CONCLUSION

The pulsation rate significantly affects the duration of the time components (phases "a", "b", "c and "d") comprising the period of one impulse.

The established inflection in the graphical profiles of all the studied variants highlights the steady operating mode of the milking units up to a pulsation rate of about 90 min^{-1}.

The presence of an internal support on the wall of the milking liner has a significant influence on the absolute duration of the pulsation phases.

Filling the milking chamber with an artificial teat reduces the absolute duration of the transitional "a" and "c" phases and prolongs the actual "b" and "d" phases in all the experimental rates.

Recommendation: The pulsation system setup and the precision of the time components of the pulsogram should be performed in the presence of an internal support in the milking chambers of the milking cups. This can be undertaken in the real milking process or by placing an artificial teat, mimicking the reaction of the support created by the natural papilla tissue. The pulsation system setups without such a support are not adequate to the actual operating conditions.

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