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ANALYSIS OF QUALITY MILKING PROCESS BY THERMOGRAPHIC METHOD

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Abstract

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The aim of the study was to determine the milking process quality through the temperature changes on teats. The measurements were conducted to evaluate the effect of partial vacuum 45 kPa and 40 kPa at the mammary gland. The measurements were done on a dairy farm at six Holstein breed dairy cows that were in the second stage of lactation. Temperature changes on teats were measured with thermal camera ThermoProTM TP8S IR during 2 days (morning milking and afternoon milking partial vacuum to 45 kPa, morning and afternoon milking with 40 kPa). The teats surface temperature was monitored before milking, after milking, 2 minutes after milking and 4 minutes after milking.
The obtained results showed the increasing temperature during machine milking at both partial vacuums (45 kPa, 40 kPa). The highest temperature was reached immediately after milking. At the partial vacuum 45 kPa, the temperature increase was in morning and afternoon milking an average of +2.44 K. At partial vacuum 40 kPa the temperature increase was +1.93 K. Both temperature increases were statistically different ($P > 0.05$). The largest temperature decrease of teats was detected just two minutes after milking. Thermographic method used to assess the quality of milking process has proved to be useful because of the teat's response to a machine milking process.

Keywords: dairy cattle, infrared thermography, mammary gland, partial vacuum, teats

INTRODUCTION

The change-over from hand milking to machine milking has brought a number of technical and biological problems, but machine milking increases productivity and cleaner milk (Tančin and Tančinová, 2008). According to these authors, the function parameters of milking system can be observed during the milking process, but also according to teats condition at the end of milking. Teat condition is main indicator of milking level and also of technological and hygienic quality of milk.

As mentioned Provolo a Sangiorgi (1998) in terms of reduced teats damage is important to reduce the milking partial vacuum level. Olejnik (2001) and Kunc (2009) summarized the influence of partial vacuum in extreme conditions. According to them the average value of partial vacuum to the teats tip is the same as the average value measured in milking claw or milk hose. The use of infrared thermography (IRT) is deemed as a feasible in milking process.

Infrared thermography can be applied in the milking process. In this area, this method is used primarily to the quality assessment of milking process, respectively impact to mammary traumatization and health assessments of mammary gland in general. Thermographic measurements of the milking process have been taken by Hamann (1985), who investigated the temperature responses of the udder to machine milking. This study showed

that conventional milking machines may cause an increase of the teat-end temperature by 2 °C. Barth (2000) and Paulrud et al. (2005) obtained increasing teat temperature during milking. Kunc et al. (2000) compared rubber liners from two producers. The results showed that milking increased the temperature of teats. The highest values were obtained immediately after milking. This trend was recorded in liners from both producers. The differences in the temperature states of teats were, however, not significant between the producers. Berry et al. (2003) proved that IRT shows potential as an early detection method for mastitis. Scott et al. (2000) found that inflammation could be detected from temperature differences by using IRT earlier with either bovine serum albumin or somatic cell counts. This supports the findings of Willits (2005) Kennedy (2004), who found that mastitis infections cause udder surface temperature to rise often before other clinical signs are observed.

The goal of the research work was to perform the milking process quality through the temperature changes on teats.

MATERIALS AND METHODS

The measurements were done on a dairy farm at six Holstein breed dairy cows that were in the second stage of lactation with average milk utility of 9827 kg per lactation.

Selected dairy cows were moved from housing to the boxing part, where the experiment was held. Boxing part was intended for individual milking with using bucked milking system with adjustable height of partial vacuum by control valve.

Temperature changes on teats and analysis of machine milking quality were measured with:

- thermal camera ThermoProTM TP8S IR,
- Guide Ir Analyser® V1.7 – thermograms analyse,
- COMET Datalogger R3120 – temperature and relative humidity measurements.

The effect of machine milking to the teat surface temperature changes was observed in partial vacuums 45 kPa and 40 kPa. The experimental dairy cows were milked twice a day (morning and afternoon). Thermographic measurements were performed in the following way:

- 1st day: morning milking – set up partial vacuum 45 kPa,
- 1st day: afternoon milking – set up partial vacuum 45 kPa,
- 2nd day: morning milking – set up partial vacuum 40 kPa,
- 2nd day: afternoon milking – set up partial vacuum 40 kPa.

Thermographic images of teats temperature were scanned for each dairy cow at the following intervals:

- before milking – A
- immediately after milking – when the milking system was removed – B
- 2 minutes after milking – 2B
- 4 minutes after milking – 4B

Before milking the teats were not treated in any way and have been made even first stripping to avoid distorting the result of the temperature profile. Thermographic images were recorded at a distance 1 m from the animal. Premilking teats preparation was carried out after the measurements. During each measurement – air temperature, relative humidity, milking period and the quantity of milked milk were measured. Thermographic images were evaluated by using Guide Ir Analyser® V1.7. Results were analysed independently using Microsoft Office Excel 2007, and Statistics complete CZ (StatSoft, USA) including ANOVA and POST-HOC Scheffe test.

RESULTS AND DISCUSSION

Temperature changes after morning milking are shown in Table I.

Immediately after milking was recorded the temperature increase in both partial vacuums. At partial vacuum 45 kPa, the increase in temperature was of 1.07 K and at 40 kPa partial vacuum it was 1.71 K. Both temperature increases were not significantly different. Two minutes after milking teats temperature decreases by 2.07 K at the partial vacuum 45 kPa and by 1.28 K at partial vacuum

I: *Statistical differences and statistical significance between 45 kPa and 40 kPa in morning milking.*

Partial vacuum [kPa]	B-A		2B-B		4B-2B		A-4B	
	$\bar{x}$ [K]	sd	$\bar{x}$ [K]	sd	$\bar{x}$ [K]	sd	$\bar{x}$ [K]	sd
45	1,07	2,75	-2,07	1,34	0,91	0,91	1,10	2,39
40	1,71	2,44	-1,28	1,02	0,86	0,86	-0,11	2,12
mean difference 45 – 40	0,64		0,79		0,05		1,21	
significant difference	NS		*0,05		NS		NS	

A – temperature before milking
B – temperature after milking
2B – temperature 2 minutes after milking
4B – temperature 4 minutes after milking
sd – standard deviation
$\bar{x}$ – mean of temperature changes, [K]

II: *Significant differences – 45 kPa vs. 40 kPa (afternoon milking).*

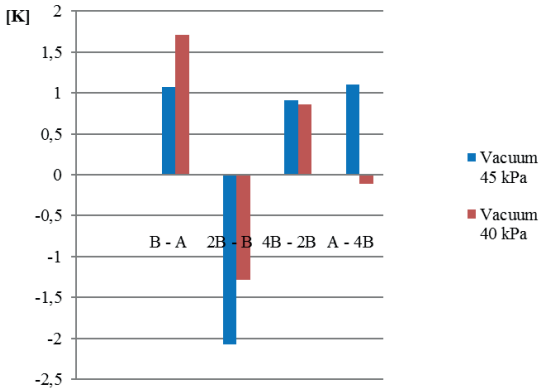
Partial vacuum [kPa]	B-A		2B-B		4B-2B		A-4B	
	x̄ [K]	sd	x̄ [K]	sd	x̄ [K]	sd	x̄ [K]	sd
45	3,62	2,09	-3,31	1,93	-0,56	1,01	0,25	3,00
40	2,13	1,15	-2,69	0,94	0,55	1,12	0,01	1,69
mean difference 45 – 40	1,49		0,62		1,11		0,24	
significant difference	*0,05		NS		*0,05		NS	

A – temperature before milking
B – temperature after milking
2B – temperature 2 minutes after milking
4B – temperature 4 minutes after milking
sd – standard deviation
x̄ – mean of temperature changes, [K]

40 kPa. Temperature increases at 45 kPa and 40 kPa were significantly different ($P < 0.05$).

The teats temperature in 4th minutes after milking were increasing tendency in comparison with decrease during 2nd minute. At partial vacuum 45 kPa temperature increases by 0.91 K and at partial vacuum 40 kPa temperature increases by 0.86 K. Different in terms of temperature development was not significant ($P > 0.05$).

In comparison of temperature changes in 4th minutes after milking and before milking was shown that the teats temperature was higher of 1.1 K at partial vacuum 45 kPa. On the other hand at 40 kPa the teats temperature was lower of 0.11 K in comparison with teats temperature before milking. Different regarding teat temperatures was not significant ($P > 0.05$). Figure 1 depicts the teats temperature changes at 45 kPa and 40 kPa.



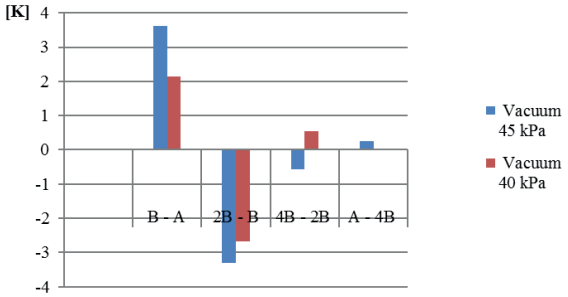
1: *Teats temperature changes at 45 kPa and 40 kPa – morning milking.*

Teats temperature changes of afternoon milking are shown in Table II.

The teats temperature increase was obtained at both measured partial vacuums immediately after milking. Partial vacuum 45 kPa recorded temperature increase by 3.62 kPa and partial vacuum 40 kPa by 2.13 K. Temperature increase at both partial vacuum were significantly different ($P < 0.05$). After 2 minutes of milking process the teats temperature decreases by 3.31 K at 45 kPa and by 2.69 K at 40 kPa. However the temperature decrease for both partial vacuums was not significantly different. In 4th minute after milking in comparison with 2nd minute after milking the temperature decrease at 45 kPa was by 0.56 K and by 0.55 K at 40 kPa. There was significant difference ($P < 0.05$).

In comparison the teats temperature changes after 4th minutes and before milking, the higher teats temperature (0.25 K) was found out at partial vacuum 45 kPa. And also at 40 kPa partial vacuum was higher teats temperature but only by 0.01 K. The partial vacuums (45 kPa vs. 40 kPa) were not significantly different ($P > 0.05$).

Teats temperature changes at 45 kPa and 40 kPa are shown in Figure 2.



2: *Teats temperature changes at 45 kPa and 40 kPa – afternoon milking.*

During two days of experiment were recorded and summarized following temperature changes (Table III).

The teats temperature increase was obtained at both measured partial vacuums immediately after milking. The teats temperature increase was at 45 kPa by 2.44 K and at 40 kPa by 1.93 kPa. Both temperature increases did not show significant difference. Two minutes after milking process the teats temperature decreases at both partial vacuums at partial vacuum 45 kPa by 2.73 K and at 40 kPa by 2.00 K. Mean of temperature decrease between 45 kPa and 40 kPa was significantly different

III: *Significant differences – 45 kPa vs. 40 kPa (summary).*

Partial vacuum [kPa]	B-A		2B-B		4B-2B		A-4B	
	x̄ [K]	sd	x̄ [K]	sd	x̄ [K]	sd	x̄ [K]	sd
45	2,44	2,72	-2,73	1,78	-0,35	0,98	0,65	2,74
40	1,93	1,88	-2,00	1,21	0,13	1,09	-0,05	1,89
mean difference 45 – 40	0,51		0,73		0,48		0,70	
significant difference	NS		*0,05		*0,05		NS	

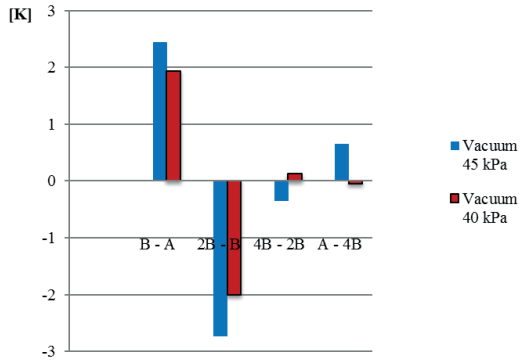
A – temperature before milking
B – temperature after milking
2B – temperature 2 minutes after milking
4B – temperature 4 minutes after milking
sd – standard deviation
x̄ – mean of temperature changes, [K]

($P < 0.05$). In 4th minute after milking process in comparison with 2nd minute the teats temperature decreased by 0.35 K at partial vacuum 45 kPa and increased by 0.13 at 40 kPa.

Different in terms of temperature development was significant ($P > 0.05$).

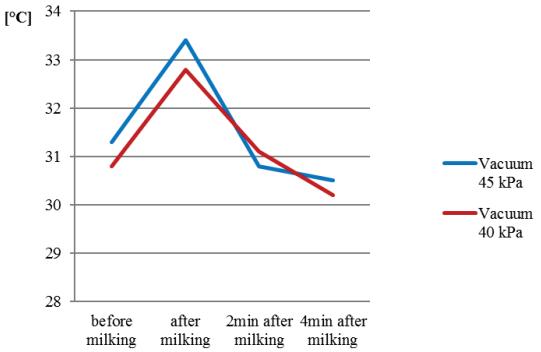
At 4th minute after milking and before milking has shown the higher teats temperature of 0.65 K at partial vacuum 45 kPa and lower temperature of 0.05 K at partial vacuum 40 kPa. Different regarding teat temperatures was not significant ($P > 0.05$).

Teats temperature changes at different partial vacuum (45 kPa, 40 kPa) are shown in Figure 3.



3: *Temperature changes differences at partial vacuums 45 kPa and 40 kPa - morning and afternoon milking.*

Teats temperature changes behaviour is depict in Figure 4.



4: *Teats temperature changes behaviour at 45 kPa and 40 kPa.*

DISCUSSION

The results show that in generall the milking process is increasing teats temperature, but the highest obtained temperature change was immediately when the teat cups were removed. The temperature increase was recorded in both partial vacuums (45 kPa, 40 kPa). What also Kunc (2009) proved that machine milking is creating teats traumatisation reflected with temperature increase immediately after milking. Similar results for dairy cows to those found by Eichel (1992), Barth (2000) and Paulrud et al. (2005). Comparison of two partial vacuums shown that higher pressure load was at higher partial vacuum, although this difference was not significantly different during whole measurement. The teats temperature increase was at 45 kPa of 2.44 K and at 40 kPa of 1.93 kPa what was also reported by Hamann (1985), who found out that by commonly used milking systems the teats temperature is increasing about 2 °C after milking.

CONCLUSION

The results showed following:

Milking process is increasing the teats temperature. These increase was recorded at both partial vacuums (45 kPa, 40 kPa). The teats temperature increase at partial vacuum 45 kPa during afternoon milking was of +2.44 K and at partial vacuum 40 kPa by 1.93 kPa. Both temperature increases did not show significant difference ($P > 0.05$).

Teats temperature increases during afternoon milking were significant different and during morning milking were not significant different.

The largest temperature decrease was found out till 2nd minute after milking, after that the only slow increase was recorded (till 4th minute of milking).
Teats temperature just after two minutes dropped to the teats temperature before milking. The difference of teats temperature drop (two minutes after milking - immediately after milking) at partial vacuums 45 kPa and 40 kPa was significant ($P < 0.05$).
Thermographic method can be regarded as a suitable method for the quality of milking process detection. The acquired knowledge and partial results is necessary to confirm in further research by measurement of larger group of animal.

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