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Artigo

Infrared thermography as diagnostic tool for bovine subclinical mastitis detection

Termografia infravermelha como ferramenta diagnóstica para a detecção da mastit e subclínica bovina

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Abstract: Forty-eight Holstein cows were assessed using infrared thermography as non-invasive diagnostic tool for subclinical mastitis detection. The temperature analysis of animals negative in the California Mastitis Test has evidenced a difference between the mean temperatures in the front and rear quarters (p=0.001). The infrared thermography comparison between the rear quarters of animals positive and negative in the California Mastitis Test has not shown any difference (p=0.236), but the comparison of results of the front quarters has shown difference between the mean temperature of the infrared thermography of positive (32.35ºC ±2.35) and negative CMTs (31.00ºC ± 2.20 (p=0.025). The use of infrared thermography as diagnostic tool seems to be promising; however, it is necessary determining a protocol to guide its use.

Keywords: Dairy Cattle; Early Detection; Non-invasive; Udder

Resumo: Foram utilizadas 48 vacas da raça Holandês com o objetivo de avaliar a utilização da termografia infravemelha como ferramenta diagnóstica, não invasiva, para detecção precoce da mastite sub-clínica. A análise das temperaturas dos animais com California Mastitis Test negativo revelou que existe diferença entre as temperaturas médias dos quartos anterior e posterior (p=0,001). A comparação da termografia infravermelha posterior de animais com Califórnia Mastite Teste positivos e negativos não revelou diferença (p=0,236), já a comparação entre os quartos anteriores demonstrou a existência de diferença entre as temperaturas médias da termografia infravermelha dos animais positivos (32,35ºC ±2,35) e negativos (31,00ºC ± 2,20 (p=0,025)). A utilização da termografia infravermelha como ferramenta diagnóstica parece ser promissora, entretanto há a necessidade de estabelecer um protocolo para sua utilização.

Palavras-chave: Detecção precoce; Gado de Leite; Não Invasivo; Úbere

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Introduction

The word 'mastitis' refers to inflammation in the mammary gland, which is featured by physical, chemical and bacteriological changes in the milk due to pathological lesion in the glandular tissue (BLOOD; RADOSTITS, 1991).Mastitis can be classified as clinical and sub-clinical (RIBEIRO et al., 2003; Martins et al., 2005); the sub-clinical are those that cause more losses to dairy farming (FONSECA AND SANTOS, 2000, Barbosa et al., 2014; Junior et al., 2014, Paula et al., 2014, Pilon et al., 2014). The diagnose methods include the Somatic Cell Count (SCC), the California Mastitis Test 9 (CMT) or the bacterial isolation (NORBERG, 2005; VINGUIER et al., 2009).

The disease's early diagnosis reduces the losses through the increase in milk production, as well as through the decrease in the amount of scraped milk due to the treatment, in the costs with veterinary and medication, in the early slaughter and in losses due to the death of infected animals, and it also increases the prices due to quality awards (WILLITS, 2005; TIMMS, 2004).

Because of the recent technological advances, the optical imaging technologies are becoming a powerful digital tool to achieve objective and non-invasive diagnosis by monitoring the applied therapies in order to guide the treatments (BALAS, 2009).

The Infrared Thermography (IT) is a non-invasive remote method used to measure the variations in blood flow measures and the heat transference through the detection of little variations in body temperature (NAAS et al., 2014).

It has been used in different diagnosis types such as the changes caused by thermal stress (COSTA et al., 2015), the production and emission of gases during ruminant production (MONTANHOLI et al., 2008), and heat detection (SAKATANI et al., 2016).

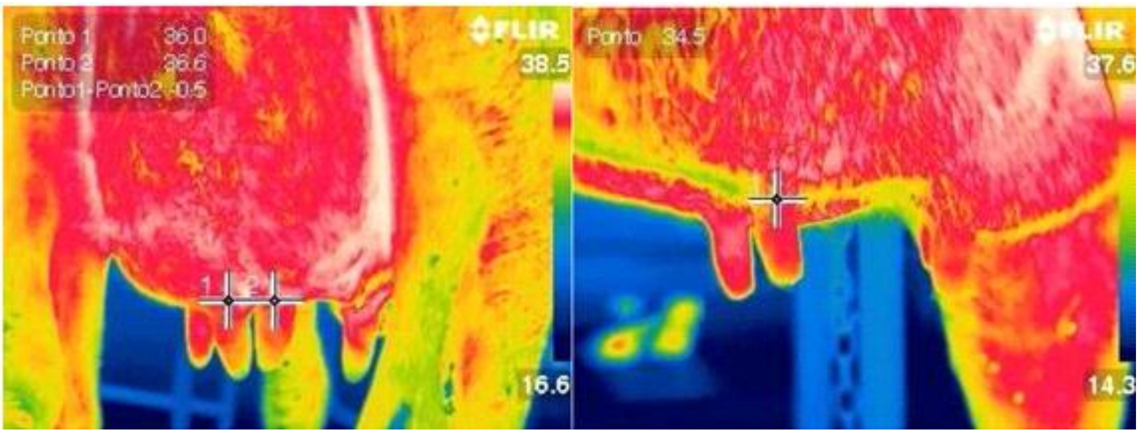
The aim of the present study is to assess the use of Infrared Thermography as a non-invasive diagnostic tool to detect early sub-clinical mastitis in dairy cows.

Material and Methods

The study was carried out in September 2014 in a farm located in Apucarana County, Paraná State - Brazil (23° 33' 03" S and 51° 27' 39" W). The meantemperature and the mean relative humidity inthis month was 20.4ºC and 71.0%, respectively. A total of 48 Holstein cows of the black and white variety were assessed. The animals were in the age groupbetween 2 and 13 years; days in milk were 240.92, on average; and the meanmilk production was 25.40 liters. Data were collected before milking, at the milking parlor, between 5:00 and 7:00 a.m. The infrared images (IT) fromthe udder's surface and from the eye region were collected while the animals restedunderthe shade. The California Mastitis Test (CMT) was applied toeach udder quarter, and the rectal temperature (RT) was taken.

The thermal images were obtained using an infrared camera (FLIR T 440®), at 0.01ºC resolution, placed 1.5 m from the animal; the emission coefficient was adjusted at 0.97 Figure 1.

Figure 1 - Infrared thermography at the caudal and lateral lateral positions.



Images from the ocular globe, from the front left quarter (FLQ), from the front right quarter (FRQ), from the rear left quarter (RLQ) and from the rear right quarter (RRQ) of the udder were recorded. The rectal temperature (RT) of each animal was measured using a digital thermometer. Subsequently, the CMT was performed and the scores ranging from 0 (the lowest) to 4 (the highest) were addressed according to precipitation level and gel formation. The recorded data of the measured variables were presented through descriptive analysis.

The continuous quantitative data were compared through analysis of variance after the required assumptions were assessed in the Minitab 16.0 statistical package software to determine the Pearson's linear correlation.

Results and Discussion

By taking all the data into consideration, regardless of the CMT result, it was possible seeing that the temperature (Tab. 1) was 31.62ºC ± 2.19, in FRQ; 30.85ºC ± 2.32, in FLQ; 32.08ºC ± 1.91, in RRQ; and 32.19ºC ± 2.01, in RLQ.

The mean temperature value was 38.32ºC ± 0.35, in RT; and 32.24ºC ± 1.33, inocular temperature (OT). Based on the variation coefficients, tone can state that the rectal temperatures were more homogeneous than the ocular ones, which were followed by the udder temperatures.

Table 1-Means, standard deviation, variation coefficient, maximum and minimum temperatures in Celsius degrees, the front right quarter (1), front left quarter (2), rear right quarter (3), rear left quarter (4), rectal temperatures (5) and the ocular temperature (6) of 24 cows negative in the California Mastitis Test (7).

Parameter	**FRQ**	**FLQ**	**RRQ**	**RLQ**	**RT**	**OT**
Mean	30.80	31.02	32.05	32.50	38.37	31.94
Standard Deviation	1.92	1.90	1.99	2.00	0.38	1.40
VariationCoefficient	6.24	6.11	6.21	6.16	1.00	4.38
Maximum	34.40	35.10	35.80	35.60	39.50	34.10
Minimum	27.30	28.20	28.60	28.10	37.80	28.60
Amplitude	7.10	6.90	7.20	7.50	1.70	5.50

1, FRQ, 2,FLQ, 3,RRQ, 4,RLQ, 5,RT, 6,OT, 7,negative CMT.

The analysis of negative CMT animals has shown difference in the mean temperatures of the front quarters in comparison to those of the rear quarters (p=0.001). The mean and standard deviation of the temperature (ºC) obtained through the infrared thermography of the front quarters was 30.91±1.89; whereas it was 32.28±1.99, in the rear quarters. However, there is no difference between the right and left sides (p=0.399).

The mean temperature recorded through infrared thermography in the right side was 31.43± 2.03; and 31.76±2.07,in the left side. There was no interaction between position and side (p=0.763). The comparison of temperatures measured through the infrared thermography of the rear quarters of animals positive and negative in the CMT has not evidenced any difference (p=0.236); the mean temperatures recorded through the infrared thermography in the rear quarters of negative and positive CMT animals were 32.03±1.96 and 32.65±1.89, respectively. The comparison between 96 front quarters of positive CMT animals and front quarters of negative CMT animals has evidenced a difference between the mean temperatures recorded through infrared thermography in the front quarters of positive CMT animals (32.35±2.35) and those of negative CMT animals (31.00±2.20 (p=0.025)). The correlation coefficient values of the mean udder surface temperature in negative animals, and the ocular and rectal temperatures were 0.577 and 0.475 (p= 0.000), respectively.

Unlike the present study, there was no difference in the temperature of the front and rear quarters. It may due to the fact that the authors have used controlled environments throughout the experiment and allowed the animals to rest for 30 minutes before the imaging tests (COLACK et al., 2008). Mastitis detection methods should take into account the daily variations under different environmental conditions depending on the changes in thetemperature of the udder skin; thus, reference baseline should be set (BERRY et al., 2003). It is worth considering the circadian oscillations in the body temperature of dairy cows, as it was already evidenced by authors such as (BITMAN et al., 1984).

According to Berry et al. (2003) the difference between the front and rear quarters may lie on the fact that the rear surface of the udder is in contact with the legs.

Studies involving sheep have also shown higher udder surface temperature in positive CMT animals (MARTINS et al., 2012). It corroborates the findings by Colak et al. (2008), who have found strong correlation (r=0.92) between udder surface temperature and CMT scores. The distribution of the 34 positive quarters was 11 in FRQ and RLQ, and 6 in FLQ and RRQ.

Thus, it resulted in 50% positive quarters between the front and rear quarters in CMT. These results contradict (BER et al., 2003), who only recorded rear quarter images, since they are more often affected by mastitis.

Although there is moderate correlation between the rectal temperature and the mean temperature in the udder, it stays within a normal range. It suggests the absence of systemic effect in positive CMT animals (COLACK et al., 2008).

Conclusion

The use of infrared thermography as a diagnostic tool to achieve early subclinical mastitis detection seems to be promising. However, a protocol to guide its use should be developed taking into account the factors interfering in the udder temperatures, such as: the time the test is performed, environmental conditions, activity, and other management practices.

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