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INTERRELATIONSHIP BETWEEN THERMAL IMAGING DATA AND DAIRY TRAITS IN RED-AND-WHITE COWS**

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Abstract: The aim of the research was the thermal imaging comparative analysis of milk production traits such as: CFU (number of micro-organism forming colonies ·1 cm^{-3} of milk), somatic cells count - SCC, content (%) of fat, protein, lactose, DM, no fat dry matter - NFDM and urea (mg·100 cm^{-3}) and the skin temperature at the selected sites on a cow's body. The research was conducted on 32 cows of Red-and-White breed, with an average milk yield 6797 kg per cow. On two sides of the body (left and right) two fixed temperature measurement sites on the joints (ankle joint, carpal joint) and 3 sites on the mammary glands (fore quarter teat cistern, hind quarter teat cistern and central ligament) were chosen as well as isotherm was drawn for the temperature distribution along the oblique body axis to record the minimal and maximal skin temperatures. Two sessions of thermal imaging photography 4 to 5 hours after morning milking were completed. An analysis demonstrated that the minimum temperatures along oblique body axis of clinically healthy cows measured on left body side relate with SCC ($r = -.788$; $P \leq 0.05$) and milk fat and DM contents ($r = +.428$ and $r = +.450$; $P \leq 0.05$). Temperature of the skin covering udder central ligament was related negatively with % content of milk fat and protein ($r = -.438$ and $r = -.442$; $P \leq 0.05$ – for the left body side).

Key words: thermography, dairy cattle, milk traits

Introduction

Thermography is a non-invasive imaging method, safe for both the examined object and the examiner and it allows one to assess the physiological condition of the examined tissues or organs due to the infrared radiation emitted by them. In all living organisms, the images of that

radiation can indirectly indicate the rate of metabolic exchange of the examined site, related to the local blood flow. As a result, thermography found an extensive use, first ascribed to the military and industrial purposes and eventually also to the human and veterinary medicine (*Barnes* 1963, *Empel* 1998).

A system of visualisation of flow field that provides theoretical basis for the study of heat and mass transfer between a cow and its environment was developed by *Wu and Gebremedhin* (2001).

Based on a herd of Red-and-White cattle the authors attempted to determine dairy traits conditioned by the environmental factors. The aim of the research was the thermal imaging comparative analysis of milk production traits and the skin temperature at the selected sites on a cow's trunk and mammary glands.

Material and methods

The research was conducted in a herd of Red-and-White cattle, with an average milk yield 6797 kg per cow, maintained in a barn-and-pasture system in the Sub-Sudety Mountain region (Przedwojów village). The animals belonged to the Ditterla family, which has been breeding the breed since 1927.

Material: 32 cows were selected on the basis of good health status and milk accepted to class extra according to the Polish Norm PN-A-86002 (colony forming units - CFU not exceeding 50 000 per 1 cm^3 and somatic cells count - SCC not exceeding 200 000 per 1 cm^3). Cows were fed TMR ration based on grass silage, grass hay and concentrates. Two sessions of thermal imaging photography (Therma CAM P65 camera), 4 to 5 hours after morning milking were completed: in December 2004 and February 2005. On two sides of the body (left and right) two fixed temperature measurement sites on the joints (ankle joint, carpal joint) and 3 sites on the mammary glands (fore quarter teat cistern, hind quarter teat cistern and central ligament) were chosen as well as isotherm was drawn for the temperature distribution along the oblique body axis (from sternum to pin bone) to record the minimal and maximal skin temperatures.

Data of milk performance for each cow from control milking in the month of thermal measurements were recorded. The comparison of skin temperatures with dairy traits such as: CFU (number of micro-organisms forming colonies per 1 cm^3 of milk), SCC, content (%) of fat, protein, lactose, DM, no fat dry matter - NFDM and urea (mg·100 cm^{-3}) was performed calculating phenotypic correlation

coefficients (*SAS* 2000).

Results and discussion

Joint results of both series of temperature measurements taken at the selected sites of the cow's udder and trunk confirm statistically significant ($P \leq 0.05$) higher average temperature within the left body side by 1.55^0C. In each relative site of measurement within the left body side, the temperature taken was higher that in its counterpart site within the right body side (Table 1): fore quarter teat cistern by + $0{,}40^0$C, hind quarter teat cistern by + 0.71^0C, udder central ligament by + 0.43^0C, ankle joint by + 3.05^0C and carpal joint by + 1.80^0C.

Table1. Mean temperature at selected sites on the cows' body (mean ± sd)

Temperature measurement site	Fore quarter teat cistern	Hind quarter teat cistern	Central ligament	Ankle joint	Carpal joint	Oblique body axis	
						temp. max	temp. min
Left side	31.66^A ± 1.364	31.54^A ± 2,554	33.54^A ± 1.240	27.56^B ± 2.449	25.89^B ± 3.575	33.64^A ± 2.240	24.22^B ± 2.270
Right side	31.26^A ± 1.326	30.83^A ± 2.848	32.21^A ± 1.727	24.51^B ±3.452	24.09^B ± 3.866	32.21^A ± 1.727	22.25^B ± 3.591

^{A,B} – means denoted with different letters differ within lines at $P \leq 0.01$

Interrelation between the temperature at the selected sites of the cow's body and the basic milk composition was calculated by means of phenotypic correlations, individually for the left and right body side measurements at the selected sites of an udder, joints and along the oblique body axis – Table 2.

Coefficients of the phenotypic correlation between the selected sites of temperature measurements and qualitative milk traits appeared to be convergent (positively or negatively). For the milk traits and selected sites of the body temperature measurements on the left body side 13 convergences confirmed by the statistically significant correlation were found. All statistically significant correlation coefficients calculated for the left body side were also significant or close to statistic significance in measurements taken within the right body side.

Content of NFDM was correlated with the maximum temperature measured along the oblique body axis ($r = -.473$; $P \leq 0.05$ and $-.349$), while relatively lower content of urea was related with the increased temperature

measured within the skin area of hind quarter teat cistern (r = -.453 and -.462; P≤ 0.05).

Thermograms are quantitative reflections of the surface temperature of the examined bodies, as the amount of energy emanated by the bodies is the function of their temperature. Normal body temperature depends on the metabolic state of an organism. Usually the surface skin temperature is lower than the temperature of the inner tissues and it depends not only on the metabolic state of an animal but also on many other factors, as: influence of other heat sources, vesicular skin activity and the activity of tissues located just under its surface, heat loss through conduction, convection and radiation (*Barnes* 1963, *Purohit and Mc Coy* 1980). *Kastelic et al.* (1996) showed the effect of physiological events in bulls on surface temperature while *Wu and Gebremedhin* (2001) stated that the direction of air movement is not an important factor in influencing the convective heat transfer between a cow and its environment.

Table 2. Coefficients of phenotypic correlation between the milk composition of cows and the temperature measured at selected sites on the cow's body and udder

Milk composition	Temperature measurement site						
	Fore quarter teat cistern	Hind quarter teat cistern	Central ligament	Ankle joint	Carpal joint	Oblique body axis	
						temp. max	temp. min
	Left body side						
CFU	-.175	**-.477**	-.129	**.409**	.074	-.124	-.311
SCC	**-.479**	-.037	-.360	-.057	-.143	-.098	**-.788**
Fat %	-.068	-.201	**-.438**	-.132	**.422**	.180	**.428**
Protein %	-.232	.019	**-.442**	-.178	.048	-.230	.117
Lactose %	.215	**.532**	.199	.055	.256	**-.423**	.331
DM %	-.050	.076	-.377	-.132	.395	-.129	**.450**
NFDM %	-.007	**.401**	-.168	-.090	.223	**-.473**	.321
Urea	.088	**-.453**	.044	.300	-.238	.307	.190
	Right body side						
CFU	-.160	-.247	-.108	.068	.127	-.168	.014
SCC	**-.475**	-.022	-.370	-.113	-.111	-.083	**-.756**
Fat %	.010	-.363	**-.502**	-.164	.259	-.066	**.535**
Protein %	-.059	-.060	-.375	-.382	.120	-.111	.126
Lactose %	.231	**.465**	.250	.064	.280	-.346	.328
DM %	.069	.115	-.391	-.212	.324	-.210	**.547**
NFDM %	.140	.328	-.056	-.208	.306	-.349	.343
Urea($g \cdot cm^{-3}$)	.053	**-.462**	.326	.101	-.168	.061	.235

bold letters – correlations statistically significant at P≤ 0,05

Conclusions

The study presented the thermal imaging comparative analysis of the cow's surface body temperatures - this is an attempt at defining a correlation between the quality and chemical analysis of milk.

An analysis between chosen milk quality parameters and measurements of the body temperature demonstrated that higher minimum temperatures along oblique body axis of clinically healthy cows relate with lower somatic cells count (SCC), while milk fat and DM contents tend to be higher then.

Temperature of the skin covering udder central ligament was related negatively with % content of such milk constituents as: fat, protein, DM, NFDM – the lower the ligament area temperature the higher their concentration in milk.

Relations found in own studies may reflect intensity of blood flow and processes in the udder and in cow's body connected with production of specified milk constituents. These relations have to be researched more extensively in the future to make better understanding of their physiological basis.

ODNOS IZMEĐU PODATAKA DOBIJENIH TOPLOTNIM SNIMANJEM CRVENO-BELIH KRAVA I MLEČNIH OSOBINA

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Rezime

Cilj istraživanja je bila komparativna analiza podataka dobijenih toplotnim snimanjem i proizvodnih osobina kao što su: CFU (broj mikroorganizama koji stvaraju kolonije ·1 cm^{-3} mleka), broj somatskih ćelija - SCC, sadržaj (%) masti, proteina, laktoze, SM, bezmasna suva materija - NFDM i urea (mg·100 cm^{-3}) i temperatura kože na odabranim mestima na telu krave. Ispitivanje je izvedeno na 32 krave crveno-bele rase, sa prosečnim prinosom mleka od 6797 kg po kravi. Na levoj i desnoj strani tela, odabrane su dve fiksirane lokacije za merenje temperature na zglobovima (gležanj i zglob prednje noge) i 3 lokacije na mlečnim žlezdama (prednja četvrt, zadnja četvrt i centralni ligament) i urađen je izoterm za distribuciju temperature duž kose

ose tela kako bi se registrovale minimalne i maksimalne temperature kože. Urađene su dve sesije toplotnog snimanja 4 to 5 sati nakon jutarnje muže. Analiza je pokazala da minimalne temperature duž kose ose klinički zdravih krava merene na levoj strain tela su u vezi sa SCC ($r = -.788$; $P \leq 0.05$) i sadržajem mlečne masti SM ($r = +.428$ and $r = +.450$; $P \leq 0.05$). Temperatura kože koja prekriva centralni ligament vimena je bila u negativnoj vezi sa % sadržaja mlečne masti i proteina ($r = -.438$ and $r = -.442$; $P \leq 0.05$ – za levu stranu tela).

Ključne reči: termografija, mlečna goveda, osobine mlečnosti

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