Antemortem stress and the variance of blood metabolites, cortisol and catecholamines in cattle

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SUMMARY

Preslaughter treatment includes various stimuli (e.g. fasting, transportation, mixing of unfamiliar animals) which are causing significant alterations in blood metabolites, cortisol or catecholamines, and subsequently may influence meat quality. It was the aim of this study, to measure biochemical blood constituents in samples taken immediately after transportation and also in samples obtained during exsanguination, and to correlate them with antemortem transportation times and waiting periods, as well as with postmortem muscle pH-values.

From 87 young Simmental bulls, blood samples were taken immediately after transportation ante mortem from the tail vena by venipuncture, and furthermore intramortem during exsanguination, and were analysed for glucose, lactate, creatinekinase, insulin, cortisol, norepinephrine and epinephrine.

Mean values for samples obtained during exsanguination showed higher levels as when compared to samples obtained by antemortem venipuncture, especially catecholamine values were dramatically increased in the intramortem samples. Relatively short transportation times did not create a clear picture considering the variations of blood constituents, probably due to overlapping effects of unloading, handling and finally stunning. Cortisol correlated with preslaughter waiting time ($r = -0.55$ ***). Post mortem ultimate muscle pH values were correlated with most of the blood constituents. Finally, there was ample variation left for effects due to the individual.

We conclude that blood samples obtained during exsanguination strongly reflect individual reactions and stunning effects by dramatically elevated catecholamine levels, and that by studying specific parameters during the critical period just prior to slaughter we may gain insights as to how we can reduce animal stress, which is known to ultimately alter meat quality.

INTRODUCTION

Numerous factors, e.g. physical activity, nutritional intake, aggression and/or infection can cause significant alterations in blood metabolites, cortisol or catecholamines.

Preslaughter treatment of cattle includes various stimuli (e.g. fasting, transportation, mixing of unfamiliar animals) which subsequently induce variations of blood constituents which can ultimately influence meat quality (LAWRIE, 1958; WARRIS et al., 1984).

The two basic concerns in the preslaughter treatment are animal welfare and postmortem meat

quality. Subsequent analysis of blood constituents may be indicative for either aspect. For example, strenuous exercise is known to increase levels of blood lactate which is the consequence of depleted glycogen stores in muscle (CROUSE and SMITH, 1986; BLUM and EICHINGER, 1988). Insulin levels may be reduced during stress so that blood glucose levels remain stable. Increased cortisol levels are indicative of prolonged stress and have lipolytic effects. Finally, elevated catecholamine levels will directly cause muscular glycogen depletion (CROUSE and SMITH, 1986) and are considered direct indicators for stress.

It was the aim of this study to measure biochemical components of blood in samples obtained from young Simmental bulls antemortem and during exsanguination, to determine their physiological correlations to preslaughter treatment and to alteration in post mortem muscle pH.

MATERIAL AND METHODS

In a large slaughter facility, blood samples were obtained from the tail vena of 87 young Simmental bulls immediately after the animal left the transportation truck. Additional samples were taken during exsanguination. Samples were kept on ice until centrifuged in the cold. Then 0.5 ml proportions of plasma were frozen at -70°C and stored at -30°C until studied. Samples were analysed enzymatically for glucose and lactate (BERGMEYER et al., 1974), by radioimmunoassay for insulin (Isotopendiagnostik CIS GmbH, Dreieich, FRG) and cortisol (DRG-Instruments GmbH, Marburg, FRG) and by HPLC technique for catecholamines (BOOS et al., 1987). Preslaughter stress was evaluated by calculating the total transportation time according to the transportation protocols. Furthermore, the time from unloading until stunning was registrated (preslaughter waiting time). After a 24 h cooling period at 4°C the intramuscular pH was measured in the m. long. dorsi electrometrically.

RESULTS AND DISCUSSION

The average transportation time was 45 $\pm$ 26 min ($\bar{x}$ $\pm$ SD) indicating rather low stress due to transportation. The period between animal unloading and stunning was 39 $\pm$ 23 min. The average carcass weight was 370 $\pm$ 40 kg, and the 24 hour postmortem pH in the longissimus dorsi muscle was 5.55 $\pm$ 0.10 (only 1 animal had a pH value higher than 6.0 which is indicative of dark-firm-dry, DFD, meat).

Shown in Table 1 are mean values of each blood constituent obtained from each of the two sampling periods, following transportation and collected during exsanguination. Lactate, glucose, cortisol, insulin and creatinekinase levels were elevated in the intra mortem samples. It should be noted that even the values obtained for these constituents following transportation were considered elevated, but there were large individual variations. Catecholamine levels were

Table 1 - Blood constituents after (A) sampling ante mortem at the tail vena and (B) intra mortem during exsanguination from young Simmental bulls and the appropriate correlation coefficients

Blood constituent	(A) ante mortem samples			(B) intra mortem samples			r between (A)and(B)
	n	$\bar{x}^a$	(s^b)	n	$\bar{x}^a$	(s^b)	
Lactate (mmol/l)	87	5.98	(3.59)	87	9.39	(3.80)	0.45***
Glucose (mmol/l)	87	5.58	(1.61)	87	7.19	(2.16)	0.70***
Cortisol (µg/l)	87	33.92	(13.04)	87	38.76	(14.10)	0.55***
Insulin (mU/l)	87	26.33	(11.58)	86	32.71	(14.63)	0.56***
Creatinekinase (logU)	87	2.08	(0.31)	87	2.17	(0.28)	0.70***
Norepinephrine (nmol/l)	83	4.37	(2.23)	87	274.3	(200.0)	0.02
Epinephrine (nmol/l)	83	2.84	(1.58)	87	146.0	(91.7)	0.12

[a] Mean [b] Standard deviation *** = $p < 0.001$

dramatically elevated in the intramortem (exsanguination) samples. The coefficients of correlation between the values of the blood constituents for the two sampling periods were highly significant, except for catecholamines which were likely biased by the animal stunning procedure.

Table 2 - Correlation coefficients between time of transportation, preslaughter waiting time, post mortem pH values and blood constituents from samples obtained by preslaughter venipuncture (VP) and during exsanguination (EX) (n = 83)

Parameter	transportation time		preslaughter waiting time	ultimate muscle pH	
	VP	EX	EX	VP	EX
Lactate	- 0.13	0.04	0.06	0.40 ***	0.27 *
Glucose	0.05	- 0.18	- 0.26 *	0.23 *	0.27 *
Cortisol	0.04	- 0.02	- 0.55***	0.06	0.01
Insulin	- 0.10	- 0.23 *	- 0.08	- 0.06	- 0.04
Creatinekinase	0.17	0.32 **	- 0.14	0.26 *	0.38 ***
Norepinephrine	- 0.19	- 0.28 *	- 0.11	0.28 **	0.17
Epinephrine	- 0.19	- 0.31 **	0.05	0.38 ***	0.06

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Coefficients of correlation between transportation time and the concentration of a given blood constituent for either sample period were generally in a lower range. They did not give a clear picture, because the relatively low transportation stress may be superimposed with unloading and stunning effects (Tab. 2). It was previously reported that the major cause of preslaughter stress was housing with unfamiliar animals (CROUSE et al., 1986; LAWRIE, 1958). However, the

transportation conditions at this experiment did not include longer mixing periods. There was a better correlation between levels of a given blood constituent and post mortem muscle pH. For example, in those animals which had higher levels of lactate or catecholamines in the venipuncture samples, the post mortem muscle pH values were also higher. Finally, we noted as did WARRIS et al. (1984) that meat with higher pH values came from animals which had elevations in blood creatinekinase levels.

CONCLUSIONS

We conclude, that by studying specific blood constituents during the critical period just prior to slaughter we may gain insights as to how we can reduce animal stress which is known to ultimately alter meat quality.

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