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GLYCOGEN DEPLETION AND CHANGES IN BLOOD METABOLITES DURING TRANSPORT AND LAIRAGE OF REINDEER (RANGIFER TARANDUS L)

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INTRODUCTION

Handling of animals before slaughter is of great importance for the meat quality. When animals are exposed to stress, their muscle glycogen stores become depleted. A low glycogen content in muscles results in a high ultimate pH in the meat. This quality effect -- known as dark cutting -- reduces shelf life, especially for vacuum-packed meat (Warriss, 1992).

The National Food Administration in Sweden has drawn up new directives regarding meat inspection at slaughter, requiring that slaughter should take place only in approved slaughterhouses. These directives also cover reindeer and consequently, many of the out-door slaughter sites will be closed and the numbers of reindeer that have to be transported will increase.

Reindeer are often exposed to several stressful situations preceding slaughter, such as rounding up, driving, transport and long lairage times, circumstances that contribute to glycogen depletion and can consequently affect meat quality. However, our knowledge in this context is very limited and further studies on the interactions between handling routines and quality of reindeer meat are therefore needed. The purpose of this investigation was to study the glycogen content in reindeer muscles during transport and lairage. In addition, several blood metabolites were screened in order to find a physiological link between muscle and blood analyses.

MATERIALS AND METHODS

Seventy reindeer cows and calves were included in the study. Blood samples were collected at exsanguination and frozen in liquid nitrogen (-196°C) after 10 minutes at most. Samples from three muscles, m.triceps bracchi (TB), m.longissimus dorsi (LD) and m.biceps femoris (BF), were taken 30 minutes after slaughter and frozen in liquid nitrogen. Ultimate pH was measured 30 minutes post-mortem. During Marc, 1992, two different reindeer herds were studied according to the following experimental design:

A small group of animals were rounded up and driven to the corral and slaughtered directly. The remainder of the reindeer selected for slaughter were transported by lorry to the slaughterhouse (Tottes Slakt AB, Harads). Half of this group of animals were slaughtered directly on arrival at the slaughterhouse. The remainder were allowed to rest for two days and they were fed hay and water ad lib before slaughter in a corral close to the slaughterhouse. The two herds investigated had very long transport distances to the slaughterhouse (more than 500km). At each slaughter occasion, muscle and blood samples were collected from five male calves and five cows. The study also included a group of six calves which were given supplementary feed for six months at the University of Agricultural Science, Uppsala.

Glycogen determination in muscle samples

The muscle samples were freeze-dried for 24 hours and then put under a dissection microscope so that connective tissue, fat and blood could be removed. Glycogen analyses were performed on 1 to 2mg of muscle tissue (Lowry and

Passoneau, 1973).

Blood metabolites

The plasma samples were analyzed in a `quick' analyzer "Analyst" (duPont Company, USA) and then the following components were measured: alkaline phosphatase, gamma-glutamyl transpeptides, aspartate aminotransferase (ASAT), alaine aminotransferase, urea nitrogen, glucose, calcium, cholesterol, triglyceride, uric acid, creatinine, bilirubin and total protein. In the following we have chosen to present urea, ASAT and creatinine, as these metabolites were most closely correlated to pH-value and glycogen content.

pH measurements

The ultimate pH-values were measured with a KNICK Portamess 651-2 pH-meter (Knick Elektronische Messegeräte GmbH & Co., Germany) equipped with an INGOLD (Ingold Messtechnik AG, Switzerland) electrode (LOT 406 M-6 Xerolyt).

Statistical analyses

The effects of herd and treatment were estimated simultaneously by the method of least-squares analysis using the GLM procedure within the Statistical Analysis System (SAS Institute Inc., 1989). The two-way interactions were tested, but were included only when significant. In addition, an analysis was made within each herd.

RESULTS AND DISCUSSION

The results from each herd are presented separately as the animals in each herd were treated differently and also differed in physical condition (Tables 1 and 2).

Herd 1

The animals from herd 1 were not given supplementary feed and were therefore not in optimal physical condition. No significant differences ($P>0.05$) in glycogen content could be confirmed between the different treatments. Ultimate pH-value for the calves which had been waiting two days to be slaughtered were higher than in calves receiving the other treatments. The urea values decreased during transport and lairage for both cows and calves, while the ASAT values increased. Creatinine values decreased for the cows and showed no differences between treatments for the calves.

Herd 2

The reindeer calves from herd 2 were fed a commercial feed mixture (Renfor) for two months before slaughter. Glycogen content in the muscles was slightly higher in this herd than in herd 1, probably due to the feeding. There were no significant differences in either glycogen content or pH-value between different treatments. The urea values increased slightly during transport and lairage while the ASAT and creatinine values showed no differences between treatments.

Reindeer slaughtered at the University of Agricultural Science

The energy status of the reindeer calves slaughtered at the university was very good, as reflected by the high glycogen values in all muscles and also in the low ultimate pH-values (Table 2). The glycogen content was significantly higher

in this group of animals than in calves from both herds 1 and 2. The values of the blood metabolites were low indicating that the animals were calm during the handling routines before slaughter.

The muscle glycogen levels observed in non-fed reindeer in this study were much lower than those found in other species such as pigs (Essén-Gustavsson et al., 1980), horse (Lindholm et al., 1974) and bulls (McVeigh et al., 1982; Wiklund et al., 1990). The fed reindeer calves from herd 2 -- and especially those slaughtered at the university -- had glycogen values comparable with glycogen values in cattle. The animals from herd 1, on the other hand, had poor glycogen stores and also high ultimate pH-values.

Essén-Gustavsson and Rehbinder (1974) found low glycogen content in m.semitendinousus from reindeer exposed to different stress factors. These factors were controlled. They consisted of manual handling and restraint during the sampling of blood and muscle biopsies, chase and physical exercise for two hours and recapture with lasso. When the animals were resting or ruminating in a corral at a reindeer station, the same authors (Essén-Gustavsson and Rehbinder, 1985) found a higher glycogen content in m.semitendinosus. Reindeer slaughtered between October and March in Finland had low glycogen values and high ultimate pH in m.vastus lateralis (Petäjä, 1983).

From the above studies, it seems that reindeer in good physical condition have enough glycogen in their muscles to guarantee ultimate pH-values within the optimal range. These animals are better prepared to tolerate various stress factors such as manual handling, lorry transport and lairage. However, reindeer are normally in their best condition in early autumn. During the winter, they often lose weight (both fat and muscle) and will therefore be more susceptible to stress factors leading to impaired meat quality. To give the reindeer supplementary feed during the winter seems to be a good way to improve their nutritional reserves and so obtain normal ultimate pH-values in the meat. The degree of tameness of the reindeer will also be increased by supplementary feeding and this plays an important role in the animal's capacity to tolerate stress (Rehbinder, 1990).

The blood metabolites aspartate aminotransferase (ASAT), urea nitrogen and creatinine, all of which indicate protein catabolism caused by stress, have been measured in reindeer (Hyvärinen et al., 1976; Nieminen, 1980; Rehbinder and Edqvist, 1981; Rehbinder et al., 1982; Essén-Gustavsson and Rehbinder, 1984). High plasma urea values can indicate catabolism of proteins due to sub-maintenance intake of energy or to stress. Hyvärinen et al. (1976) measured serum values during herding of reindeer and found that the urea values increased remarkably during long driving distances and long lairage times. High plasma urea values were also found in reindeer subjected to manual handling, restraining and capturing with lasso (Rehbinder and Edqvist, 1981; Essén-Gustavsson and Rehbinder, 1984). In addition, animals that were stressed had elevated plasma cortisol levels which could have affected the catabolism of proteins. ASAT activity has also been demonstrated to increase when reindeer are herded, driven and manhandled (Hyvärinen et al., 1976; Rehbinder and Edqvist, 1981; Rehbinder et al., 1982; Essén-Gustavsson and Rehbinder, 1984; Nieminen, 1980). Serum creatinine values can have been used to monitor renal function but increased creatinine values can also indicate protein catabolism during starvation. Nieminen (1980) studied seasonal changes in blood composition of reindeer and found that serum creatinine was relatively stable throughout the year, even though the values increased slightly during the winter when the reindeer had poor energy stores.

From the present study we can conclude that supplementary feeding of reindeer will not only increase their glycogen stores, but also decrease the blood metabolites used as markers for protein catabolism or general stress. The fed animals from herd 2 and those slaughtered at the university had significantly lower values of all three blood metabolites than animals from herd 1. This indicates that the total energy balance of those animals will be improved when they are given supplementary feed, so that stress factors such as transport and lairage can be sustained without the need to use muscle protein as an energy resource.

Further studies are needed to determine real resting values for the glycogen content and the blood metabolites by killing reindeer unaffected by handling procedures. Other handling routines should also be investigated, such as rounding up and driving by means of helicopter and snow-scooter, so that the glycogen depletion occurring during each stage moment can be determined.

CONCLUSION

Reindeer in good condition with filled glycogen stores can be transported, even for very long distances, and lairaged for at least two days in a corral near the slaughterhouse without any negative effects on the ultimate pH.

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REFERENCES

ESSEN, B., LINDHOLM, A, and PERSSON, S. 1980. The effect of exercise and anabolic steroids on enzyme activities and fibre composition in skeletal muscles of pigs. Proc. Meeting Academy Society for Large Animal Medicine. Glasgow. Sept 8,9.

ESSÉN-GUSTAVSSON, B., and REHBINDER, C. 1984. The influence of stress on substrate utilization in skeletal muscle fibres of reindeer (Rangifer Tarandus L). Rangifer. 4(1):2-8.

ESSÉN-GUSTAVSSON, B., and REHBINDER, C. 1985. Skeletal muscle characteristics of reindeer (Rangifer Tarandus L). Comp. Biochem. Physiol. 82A(3):675-679.

HYVÄRINEN, H., HELLE, T., NIEMINEN, M., VÄYRYNEN, P., and VÄYRYNEN, R. 1976. Some effects of handling reindeer during gathering on the composition of their blood. Anim. Prod. 22:105-114.

LINDHOLM, A., BJERNSELD, H., and SALTIN, B. 1974. Glycogen depletion pattern in muscle fibres of trotting horses. Acta Physiol. Scand. 90:475-484.

LOWRY, O.H., and PASSONNEAU, J.V. 1973. A flexible system of enzymatic analysis. Academic Press. New York.

McVEIGH, J.M., TARRANT, P.V., and HARRINGTON, M.G. 1982. Behavioral stress and skeletal muscle glycogen metabolism in young bulls. J. Anim. Sci. 54(4):790-795.

NIEMINEN, M. 1980. The composition of reindeer blood in respect to age, season, calving and nutrition. Dissertation, University of Oulu, Finland.

PETÄJÄ, E. 1983. DFD meat in reindeer meat. 29th European Congress of Meat Research Workers. Parma, Italy.

REHBINDER, C., and EDQVIST, L.-E. 1981. Influence of stress on some blood constituents in reindeer (Rangifer Tarandus L) Acta. vet. scand. 22:480-492.

REHBINDER, C., EDQVIST, L.-E., LUNDSTRÖM, K., and VILLANFAÑE, F. 1982. A field study of management stress in reindeer (Rangifer Tarandus L). Rangifer. 2(2):2-21.

REHBINDER, C. 1990. Management stress in reindeer. Rangifer. Special issues #3.

SAS INSTITUTE INC. 1989. SAS/STAT User's Guide. Version 4. 4th edition, volume 2. SAS Institute Inc. Cary, NC.

WARRISS, P.D. 1992. Animal welfare -- handling animals before slaughter and the consequences for welfare and

product quality. Meat Focus International. July.

WIKLUND, E., MALMFORS, G., ESSÉN-GUSTAVSSON, B., and LINDHOLM, A. 1990. Glykogenförbrukning och stress hos nötkreatur i samband med slakt. Proc. Nordiska jordbruksforshares förening. Seminarium 183 "Köttkvalitet hos våra slaktdjur," Uppsala, Sweden.

Table 1. Glycogen content and ultimate pH-value in LD and urea, ASAT and creatinine values (LSMEANS) in plasma from reindeer cows and calves from herds 1 and 2.

↓ Trait	Animal Cat'y	Number Transp.	Trans. > 500km Direct Slaughter	Lairage 2 days
Herd 1:				
glycog, mmol/l	cow	110[a]	146[a]	157[a]
	calf	110[a]	189[a]	111[a]
pH-value	cow	5.89[a]	5.74[a]	5.77[a]
	calf	5.87[ab]	5.75[a]	5.90[b]
urea, mmol/l	cow	23.0[a]	18.2[ab]	12.7[b]
	calf	23.4[a]	21.3[a]	13.9[b]
ASAT, u/l	cow	177[a]	211[a]	255[b]
	calf	115[a]	276[b]	217[ab]
creat., µmol/l	cow	293[a]	248[b]	183[c]
	calf	248[a]	240[a]	207[a]
Herd 2:				
glycog, mmol/l	calf	228[a]	355[b]	205[a]
pH-value	calf	5.53[a]p	5.66[b]	5.60[a]
urea, mmol/l	calf	5.2[a]	9.0[b]	9.0[b]
ASAT, u/l	calf	179[ab]	225[a]	131[b]
creat., µmol/l	calf	133[a]	137[a]	128[a]

Values within animal category with the same letter are not significantly different (P>0.05).

Table 2. Glycogen content and ultimate pH-values in three muscles: LD, BF and TB, and urea, ASAT and creatinine values (LSMEANS) in plasma from reindeer calves slaughtered at the university.

	Muscle LD	BF	TB	Urea mmol/l	ASAT u/l	Creat. µmol/l
pH1	5.36[a]	5.46[b]	5.60[c]	5.7	128	132
Gloyco., mmol/kg	466	503	348			

Values with the same letter are not significantly different (P>0.05).