

# EFFECTS OF STRESS ON MEAT QUALITY OF REINDEER

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**Abstract** – Totally 40 reindeer calves from two groups, either slaughtered at a stationary plant (n=20) or at a field abattoir (n=20), were compared. Blood samples were obtained at slaughter for analysis of stress related metabolites. The *M. Semimembranosus* muscle from each carcass was collected for measurement of instrumental color and descriptive sensory analysis. Higher levels of cortisol and aspartate aminotransferase (AST) were found in the samples from the field abattoir. The majority of muscle samples from these animals had also pH above 5.8 and darker muscle color which indicated higher level of stress at the field abattoir. Eleven sensory parameters were significantly different between these slaughter locations including tenderness and gamy flavor. Lorry transport for the group slaughtered at the stationary abattoir was anticipated to induce higher stress level for these animals. However, the opposite result was found. A likely explanation could be that all calves were weighed shortly before slaughter at the field abattoir. Removal of this operation would probably improve the meat quality from this abattoir.

**Key Words** – Cortisol, Lorry transport, pH, Sensory evaluation

## • INTRODUCTION

Reindeers (*Rangifer tarandus tarandus*) are semi-domesticated and live their entire life as free-ranging animals. They are well adapted to the seasonal variation in feed and climate found in the northern parts of Scandinavia where the temperature at winter can go below minus 40°C. During summer the animals consume fresh grass, sedges and herbs, whereas lichen is their main feed source during winter. The reindeers in Norway are extensively raised and almost never given supplemental feeding. Due to this diet reindeer meat has a significant “gamy” flavor [1]. Today most of the reindeers are slaughtered at stationary abattoirs, but there are also a significant proportion of animals which are slaughtered at mobile units in the field. It is sometimes claimed that meat from reindeers transported by lorry before slaughter get an unpleasant “stress-taste”. However, the animals are normally exposed to a large number of stressing activities prior to slaughter which means possible off-flavor could also be induced by other factors than road transport. For instance helicopters are regularly used to drive the herds of reindeers from their grazing area to the gathering or slaughter location. Such driving may continue for several days before they finally are herded into corrals. During the sorting calves are usually weighed and ear-tags are given to those who are not selected for slaughter. To be handled by humans are particularly stressful for reindeers since they normally have very limited contact with people [2].

The purpose of the present study was to compare stress level and meat quality from reindeers exposed to road transport by lorry with animals slaughtered in the field.

## • MATERIALS AND METHODS

Totally 40 reindeer calves from two districts in Mid-Norway were included in this study. All

calves were harvested in September 2012, when the animals were approximately 5-6 months old. Half of the animals were slaughtered at an outdoor field abattoir located in the mountain area. These animals were not transported by lorry. The other 20 calves came from a neighboring district and were transported approximately 5 hours by lorry to a stationary abattoir specialized for slaughtering of reindeer. Both groups had been driven by helicopter. At both locations the calves were kept overnight in outdoor enclosures together with the other animals selected for slaughter from their herd. The reindeers at the field abattoir were exposed to human handling several times (for sorting and weighing) shortly before slaughter. The other group was weighed several days ahead and was quickly handled by the operators at the abattoir.

All animals were stunned with a penetrating captive bolt and blood samples were collected during the first seconds of bleeding.

All carcasses were excised at the same plant, which means the carcasses harvested at the field abattoir were transported 24 hours post mortem to the stationary plant. The *M. semimembranosus* (SM) from the left side of each carcass was packed in vacuum sealed plastic bags and transported at 4°C to Nofima AS.

Blood samples were used for measurement of cortisol, aspartate aminotransferase (AST) and creatine kinase (CK). Cortisol was measured by Electrochemiluminescence immune-assay (ECLIA) on Roche E 170 Modul (Roche Diagnostics, Mannheim, Germany). Enzymatic activity of AST and CK were assessed with an ADVIA1800 instrument (Siemens, Erlangen, Germany).

Muscle pH was measured 7 days post mortem, before the samples were frozen, by inserting a glass-stick probe (InLab®Solids, Mettler Toledo Intl. Inc., Greifensee, Switzerland), connected to a pH meter (Portamess 752 Calimatic, Knick, Berlin, Germany) into the muscle. The muscle samples were stored at -40°C for approximately 2 months before thawing and further analyses.

Instrumental color measurements were performed with a Minolta Chroma meter CR-300 (Minolta Camera Co., Osaka, Japan) on raw muscle slices which had bloomed at 20°C for 30 minutes prior to recording. Sensory evaluation was performed on the same slices that were used for color measurement. The meat samples were heat treated to a core temperature of 67°C before sensory evaluation with a trained panel of 10 assessors using a Descriptive Analysis (ISO-6564-1985-Methodology-Flavor Profile). All sensory attributes were assessed on a scale from 1 (low intensity) to 9 (high intensity). The sensory data were analyzed by univariate Analysis of Variance (ANOVA) using SAS 9.1 software package. Other data were analyzed by one-way ANOVA using Minitab 16.1 software.

## • RESULTS AND DISCUSSION

### *Carcass characteristics*

The reindeers slaughtered at the field location had significantly ( $p < 0.001$ ) higher carcass weight (25.7 kg) compared with the stationary abattoir (17.9 kg). This result was unexpected since these locations usually have animals of approximately the same weight. The discrepancy in weight could probably be explained partly by differences in pasture quality during summer, but also by unfavorable weather conditions at the time of harvesting. Due to strong wind and snow only a small group of approximately 60 animals were delivered to the stationary abattoir the day our study was conducted. Unfortunately these animals were lighter than the average weight for the area. Since reindeers are raised extensively without supplemental feeding variation in weight between different pasture areas are well known [3, 4]. According to the plan for this study there should have been equal number of male and female calves. However, only 6 female

calves were slaughtered at the stationary abattoir which resulted in an unbalance between genders. The average weight for the males was 22.4 kg while the females had an average weight of 20.8 kg, but these values were not significantly different.

#### *Metabolites from blood samples*

Mean values for the measured blood metabolites are shown in Table 1. Surprisingly, higher ( $p < 0.05$ ) levels of both cortisol and AST were found for samples obtained at the field abattoir compared to the stationary plant. The creatine kinase (CK) activity was not significantly different between locations, although the numerical values for this parameter also tended against higher stress level for the animals at the field location. Since the animals slaughtered at the field abattoir not had been transported by lorry it was expected lower stress response for these animals. Wiklund et al. [5] reported higher levels of AST for reindeers which had been transported more than 500 km on lorry compared to a control group without transport. In that study adult females had AST activities of 298 U/L after transport which is numerically higher than the present study. Wiklund et al. included also a group of animals which were kept in corrals for 2 days after lorry transport. The AST activity for that group was 133 U/L, which is roughly at the same level as the field slaughtered reindeers of the present study. A possible explanation for higher AST and cortisol levels for the field slaughtered animals could be stress caused by the weighing operation shortly before slaughter. In contrast the animals slaughtered at stationary abattoir had been weighed several days ahead of slaughter which means stress induced by the weighing not influenced the blood parameters. Another factor which may have affected the results could be noise from a helicopter which was located at the field abattoir. Due to bad weather the helicopter which should localize and drive the animals were not able to take off from the ground, but it made several attempts.

Table 1 Blood metabolites

Parameter	Field abattoir	Stationary plant
Cortisol (nmol/L)	219.8 ( $\pm 93.7$ )	161.7 ( $\pm 69.0$ )
AST (U/L)	144.3 ( $\pm 20.3$ )	118.7 ( $\pm 35.4$ )
CK (U/L)	889.3 ( $\pm 365$ )	731.6 ( $\pm 368$ )

#### *Instrumental color and pH*

All three Minolta parameters had significantly different ( $p < 0.001$ ) values between the two slaughter locations, Table 2. Muscles from the field abattoir had darker color than cuts from the stationary plant. The color values obtained at the stationary abattoir agrees well with values reported by Mielnik et al. [6] who excluded reindeers with pH above 6.0 from their study. The present color values agree well with the pH measured in the muscles, where 5 samples only from the field location had pH below 5.8. Usually muscles with final pH above 5.8 are classified as DFD, which means the majority of samples from the field location fell into this category. Correspondingly all samples except 2 slaughtered at the stationary plant had ultimate muscle pH below 5.8. Both AST and CK activities were negatively correlated to all color parameters which supports the perception that animal stress increase the proportion of DFD incidences.

Table 2 Muscle color and pH

Parameter	Field abattoir	Stationary plant
L* (lightness)	28.4 ( $\pm 2.2$ )	34.0 ( $\pm 2.3$ )
a* (redness)	17.8 ( $\pm 2.5$ )	21.7 ( $\pm 1.9$ )
b* (yellowness)	7.4 ( $\pm 2.2$ )	11.2 ( $\pm 2.0$ )

pH (7 days p.m)	5.95 ( $\pm 0.22$ )	5.69 ( $\pm 0.20$ )
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### *Sensory profile*

The sensory evaluation included 26 different taste and flavor parameters, where significant differences were found for 11 of them, Table 3. Samples from the field abattoir obtained higher values for both Hue and Color intensity which corresponds well with the instrumental color recordings. Although the Minolta measurements were obtained on raw samples and the sensory color intensity was evaluated on cooked samples a correlation coefficient of -0.40 was found. High values for Sharp odor and Sickeningly sweet odor are usually not desired for meat samples. In the present study these properties were more distinct for the samples slaughtered at the field abattoir, but they were not significantly correlated to any of the blood metabolites. However, Sharp flavor was correlated ( $r=0.34$ ,  $p=0.33$ ) and Sickeningly sweet flavor tended ( $r=0.29$ ,  $p=0.07$ ) to correlate to cortisol content. Both AST and cortisol were negatively correlated to Metallic odor. Reindeer meat is known to be very tender and both locations had high score values for Tenderness. Still there were significantly ( $p<0.001$ ) higher score values for the meat samples obtained at the field abattoir. Gamy flavor, which is a positive property for reindeer meat, was also rated higher ( $p=0.03$ ) for samples from the field location. Since the two groups of reindeers had been grazing in different regions it cannot be excluded that diet influenced to the differences in sensory attributes. Mielnik et al. [6] found differences in odor and flavor when they studied reindeer meat from north and mid Norway. The weight of the animals were also unlike between the two groups so this factor could not be excluded either.

Table 3 Sensory attributes, where significant ( $p<0.05$ ) effects were obtained.

Parameter	Field abattoir	Stationary plant
<i>Odor properties</i>		
Livery odor	4.6 ( $\pm 0.5$ )	4.0 ( $\pm 0.4$ )
Sharp odor	4.1 ( $\pm 0.6$ )	3.2 ( $\pm 0.3$ )
Sickeningly sweet odor	3.6 ( $\pm 0.4$ )	3.2 ( $\pm 0.3$ )
<i>Flavor properties</i>		
Livery flavor	4.6 ( $\pm 0.5$ )	3.7 ( $\pm 0.4$ )
Sharp flavor	3.4 ( $\pm 0.6$ )	2.7 ( $\pm 0.2$ )
Gamy flavor	5.3 ( $\pm 0.4$ )	4.7 ( $\pm 0.4$ )
Residual flavor	5.7 ( $\pm 0.2$ )	5.5 ( $\pm 0.2$ )
<i>Color properties</i>		
Hue	7.3 ( $\pm 0.3$ )	6.9 ( $\pm 0.3$ )
Color intensity	5.7 ( $\pm 0.5$ )	5.1 ( $\pm 0.6$ )
<i>Texture properties</i>		
Tenderness	6.7 ( $\pm 0.7$ )	6.0 ( $\pm 0.7$ )
Hardness	3.6 ( $\pm 0.4$ )	3.9 ( $\pm 0.5$ )

### • CONCLUSION

Reindeers slaughtered at the field abattoir had higher levels of cortisol and AST in blood compared with animals slaughtered at the stationary plant. Muscle color and pH indicated also higher level of stress for the animals harvested at the field location. Descriptive sensory analysis revealed differences for 11 attributes. Human handling shortly before slaughter seems to be more stressful for reindeers than lorry transport.

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