Sensory meat quality traits of reindeer (*Rangifer tarandus tarandus* L.) longissimus muscle as affected by ultimate pH

F.J.M. Smulders* and E.M. Wiklund**

* Institute for Meat Hygiene, Meat Technology and Food Science, Veterinary Medical University at Vienna, Veterinärplatz 1, 1210 Vienna, Austria

** Swedish University of Agricultural Sciences, Department of Food Science, PO Box 7051, S-750 07 Uppsala, Sweden

Introduction

Reportedly, the biological events in reindeer (*Rangifer tarandus tarandus L.*) muscle are influenced by animal husbandry and -handling (Wiklund et al., 1996a, 1997a). The semi-domestic production of reindeer meat involves relying on a mixture of traditional and modern reindeer husbandry practices, including pre-slaughter supplementary feeding, selection of individual animals by use of a lasso, long lorry transport and industrialised slaughter (Malmfors and Wiklund, 1996). As a result, distinct levels of muscle glycogen prevail, which (through their effects on ultimate pH values) have significant effects on eating quality - particularly texture (Barnier et al., 1996, Wiklund et al., 1996b, 1997b) - and on the microbiological condition of reindeer meat (high pH_{ult} rendering meat which spoils easily; Wiklund and Smulders, 1997). Sofar, studies have less concentrated on the effects of ultimate pH on other major sensory properties. This paper includes preliminary results of a study on these quality traits.

Materials and Methods

From the commercial supply a total of 15 carcasses of reindeer bulls (age 1.5 years) was selected with various ultimate loin pH values, as assessed at 35 h post mortem. On this basis three pH_{ult} groups were formed: 'Low pH_{ult}' (≤ 5.70; n=5), 'Medium pH_{ult}' ($5.71 \leq x \leq 6.10$; n=5) and 'High pH_{ult}' (> 6.10; n=5). After excision of the longissimus muscle between the 6th rib and the 6th lumbar vertebra, muscles were vacuum packaged and randomly assigned to chilled storage during either 3, 7 or 14 days, after which they were frozen at -20 degrees C, before being transported to the laboratory for further examination. The day prior to analysis samples were put in a 2°C refrigerator for overnight thawing. Variables measured included: drip loss, cooking loss, transmission value, Minolta L^*,a^*,b^* colour values, myofibrillar fragmentation index (MFI), sarcomere length and shear force, essentially following procedures described by Geesink (1993). Statistical analysis was carried out with the Statistical Analysis System (SAS Institute, Release 6.12) using the MIXED procedure. In the model the fixed effect of storage time, the random effect of animal and the interaction (pH group x storage time) were included.

Results and Discussion

Fig 1 is a graphic representation of the pH and temperature decline in the longissimus muscle of the various pH_{ult} groups, early- and at 35 h post mortem. Glycolysis proceeded more rapidly than usually seen in other ruminant species, as was also observed in earlier studies (e.g. Wiklund et al., 1996a).

Table 1 includes the results of the physical-chemical analysis of muscle traits related to eating quality. Expectedly, over the entire storage period higher pH_{ult} values resulted in significantly lower Minolta L^* values. Minolta b^* values, indicating the blue-yellow component of colour, were lower in samples stored 7 and 14 days. Transmission values of the medium and high pH_{ult} groups differed significantly from those of the low pH_{ult} group, whilst extended storage effected higher values in the low pH_{ult} group only. However, the increased protein denaturation in the latter group indicated by this observation, was not significantly correlated with drip loss, as opposed to other meat species [e.g. Den Hertog-Meishke et al. (1997b)]. Generally, drip losses - regardless of pH_{ult} or storage period - were remarkably low, especially when one considers that in veal or beef loins after extended vacuum storage and measured under similar conditions, values in the order of magnitude of 3 to 7 % are observed [e.g. den Hertog-Meishke et al. (1997)]. Cooking loss indicates the release of intra- and extra-cellular water from the matrix as well as heat-induced changes in protein structures, and hence drip loss is rarely positively correlated with cooking loss. As reported earlier by Honikel (1992), meat with distinctly higher pH_{ult} will result in lower cooking losses. The latter is further illustrated by our results. Expectedly, shear force values - although rather low in all samples, regardless of pH_{ult} - generally decreased with higher pH_{ult}. This finding once more confirms that DFD meat is more tender than meat with normal pH_{ult}. As a result of proteolytic activity [described in greater detail for a similar experiment by Wiklund et al. (1997b)], extended storage caused further tenderisation and a gradual shift in contrasts in tenderness between the various groups. Wiklund et al. (1997b) did not observe significant differences in tenderness in their study. However, they argued that the limited range in pH values might have prevented such. In the present experiment, where the pH range was much bigger, tenderness contrasts between the various pH_{ult} were indeed pronounced. MFI values suggest a similar degree of myofibrillar proteolysis in all pH groups during the first 3 days of storage. However, as the reliability of the MFI test has been disputed in recent years, the results of further, more decisive tests on protein fragmentation over the entire storage trajectory need to be analysed to allow confirmation of the validity of this statement. The results of sarcomere length measurements are not included in Table 1. Laser diffraction yielded unreliable results (diffraction bands were observed in few samples only). Subsequent examination of the samples with phase-contrast microscopy revealed that in most samples a regular striation pattern was present in 10-20% of the fields of view only. This suggest that in many samples super-contraction had occurred, disrupting the regular myofibrillar structure and rendering diffraction physically impossible. The latter observation makes suggestions on post mortem contraction phenomena rather speculative.

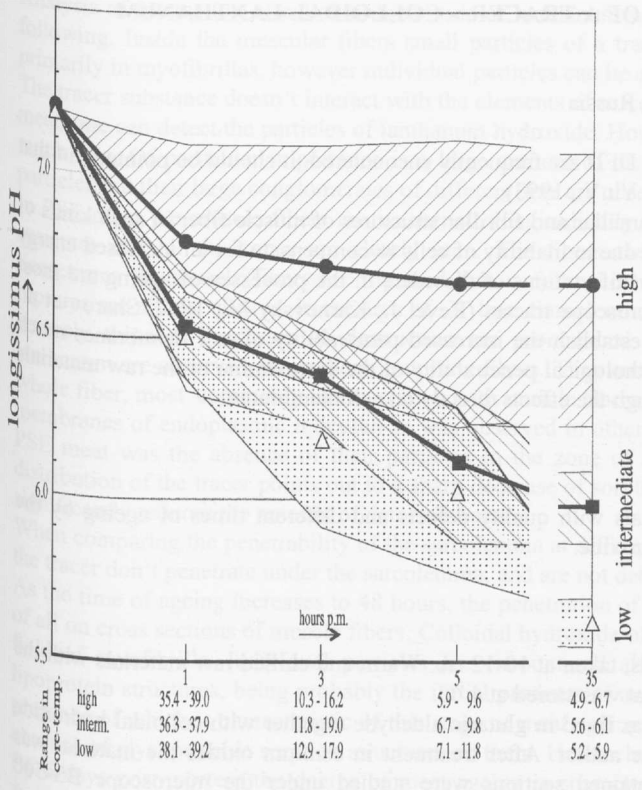

Figure 1

Post mortem evolution of pH (means and standard deviations) and temperature (minimum-maximum ranges) in reindeer longissimus muscle of various ultimate pH (n=5 in each subgroup)

TRAIT	Low pH (pH ≤ 5.70)	Medium pH (5.71 ≤ pH ≤ 6.10)	High pH (pH > 6.10)
Minolta L*			
3 days	$30.1^{a}\pm0.9$	$26.0^{b1}\pm1.2$	$26.5^{b}\pm0.9$
7 days	$30.4^{a}\pm0.9$	$5.7^{b12}\pm1.2$	$26.8^{b}\pm0.9$
14 days	$30.3^{a}\pm0.9$	$25.1^{b2}\pm1.2$	$26.7^{b}\pm0.9$
Minolta a*			
3 days	11.4±1.0	13.0±1.3	11.1±1.0
7 days	11.5±1.0	13.1±1.3	10.8±1.0
14 days	11.4±1.0	13.1±1.3	11.3±1.0
Minolta b*			
3 days	5.8±0.8	5.1±1.0	3.8±0.8
7 days	$6.2^{a}\pm0.8$	$5.3^{ab}\pm1.0$	$3.7^{b}\pm0.8$
14 days	$6.2^{a}\pm0.8$	$5.2^{ab}\pm1.0$	$3.9^{b}\pm0.8$
Drip loss (%)			
3 days	1.1±0.1	1.1±0.2	1.1±0.1
7 days	1.2±0.1	0.9±0.2	1.1±0.1
14 days	1.0±0.2	0.9±0.2	1.1±0.2
Transmission (%)			
3 days	$14.4^{a1}\pm2.1$	$5.9^{b}\pm2.7$	$2.3^{b}\pm2.1$
7 days	$15.8^{a2}\pm2.1$	$6.3^{b}\pm2.7$	$2.6^{b}\pm2.1$
14 days	$16.4^{a2}\pm2.1$	$6.1^{b}\pm2.7$	$2.6^{b}\pm2.1$
Cooking loss (%)			
3 days	$18.8^{a}\pm2.3$	$14.0^{ab}\pm3.0$	$10.4^{b}\pm2.3$
7 days	$17.8^{a}\pm2.4$	$14.6^{ab}\pm3.0$	$10.6^{b}\pm2.3$
14 days	$18.6^{a}\pm2.4$	$14.1^{ab}\pm3.2$	$11.8^{b}\pm2.4$
MFI			
20 min	$16.4^{1}\pm3.9$	$19.8^{1}\pm6.1$	$23.8^{1}\pm3.9$
3 days	$42.5^{2}\pm4.3$	$48.0^{2}\pm6.1$	$36.5^{2}\pm3.9$
Shear force (kg/cm²)			
3 days	$5.3^{a1}\pm0.6$	$4.8^{a1}\pm0.6$	$2.4^{b}\pm0.6$
7 days	$4.0^{a2}\pm0.7$	$3.8^{ab12}\pm0.6$	$2.1^{b}\pm0.6$
14 days	$4.0^{a2}\pm0.6$	$3.1^{ab2}\pm0.6$	$2.0^{b}\pm0.6$

Within rows, means with superscripts not containing a common letter differ significantly ($p < 0.05$)
Within columns and traits, means with superscripts not containing a common number differ significantly ($p < 0.05$)

Table 1

The effects of ultimate pH of reindeer longissimus muscle on physical-chemical variables relating to eating quality (n=5 in each subgroup; least square means and standard errors)

Conclusions

Distinct differences in pH_{ult} in loin muscle, resulting from different ante mortem levels of glycogen, affect eating quality of reindeer meat considerably. High pH_{ult} samples had the darkest colour, lowest cooking loss and the lowest shear force. Yet, animal welfare and microbiological considerations dictate paying special attention to proper animal treatment to avoid the DFD condition.

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