DFD MEAT IN REINDEER MEAT

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The incidence of DFD meat in reindeer meat is known, but when we looked for reindeer meat of normal pH for new reindeer meat products we met with a serious DFD problem. Because DFD meat cannot be used for cold smoked reindeer meat (Petäjä,1982), another main reindeer product, it causes many problems during the processing of that product. Therefore the real incidence of DFD meat in reindeer meat and the reasons for its existence were investigated.

THE INCIDENCE OF DFD MEAT IN REINDEER

Carcasses were taken from the slaughter sites to the buyer 1-2 days after slaughtering. The pH value was measured between 24 and 28 hours after slaughter. If the carcasses were frozen they were thawed to 0 °C before measuring. The Vastus lateralis muscle was chosen as the measuring point. The highest pH values had been found in this muscle. pH values were grouped for different pH levels according to Table 1.

Table 1. The pH ranges used in this study, and the names assigend to them.

pH value	Name of region	Common name
- 5.79	Normal meat, lower pH region	Normal meat
5.80 - 9.99	Normal meat upper pH region	
6.00 - 6.39	Slightly DFD	DFD meat
6.40 -	Strongly DFD	

Investigations were carried out into the effect on the development of DFD meat of 1) the month of slaughter (October-March), 2) the area (southern, central and northern Lapland) 3) the type of animal slaughtered.

Southern Lapland

In October the proportion of DFD carcasses was under 20 % (Fig. 1). In November the figure had increased to about 30 %. In December most of the young bulls had DFD meat but otherwise the content of DFD carcasses increased only a little. In January the percentage of DFD carcasses had increased to 70 %, of which half had very high pH values (pH > 6.4).

Central Lapland

There is only a small amount of material from central Lapland. In December, for example, the carcasses of only 27 reindeer calves were measured. The increase in the percentage of DFD carcasses is very distinct in the case of calf carcasses, from about 10 % to 90 %. No figures for reindeer slaughtered in January were obtained from central Lapland.

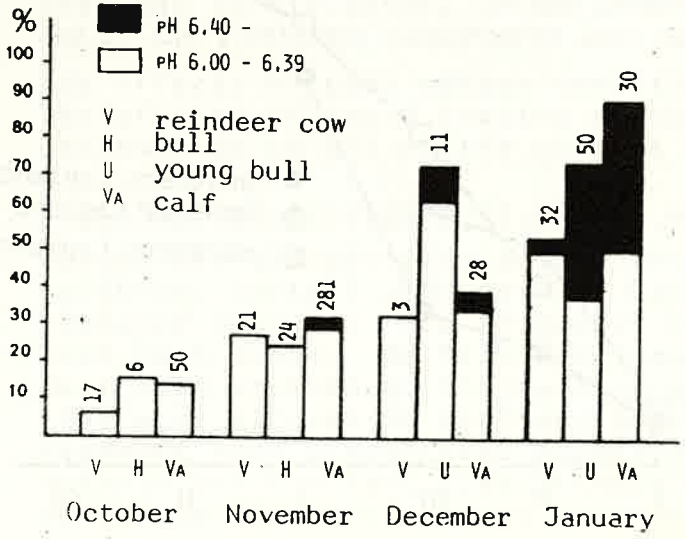

Fig. 1. DFD meat in reindeer from southern Lapland in different months.

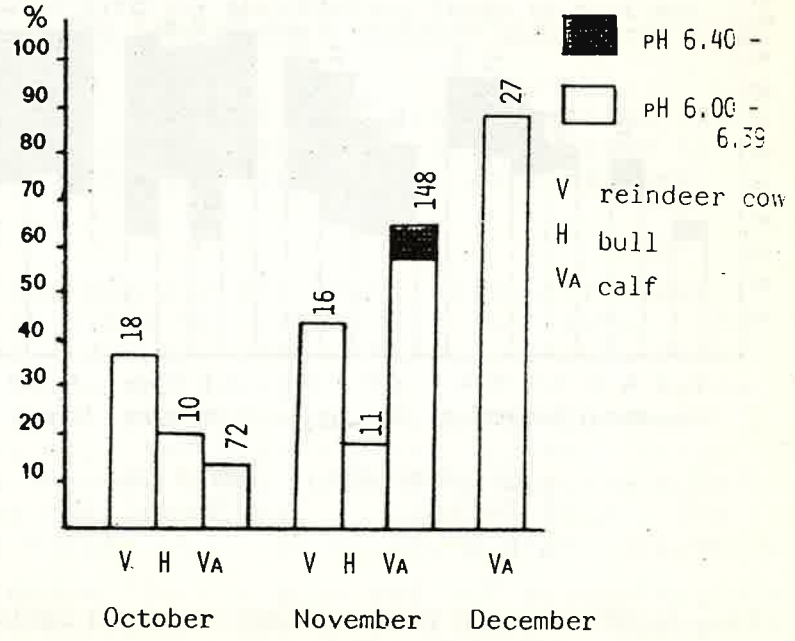

Fig. 2. DFD meat in reindeer from central Lapland in different months.

No figures were available for reindeer slaughtered in October. In November the percentage of DFD carcasses was 60 in calves and about 40 in bulls (Fig. 3). In December the proportion of DFD carcasses increased to over 80 % although it remained at 70 % in reindeer cows. In December the difference in the incidence of DFD meat between southern and northern Lapland was at its greatest. This is also shown by the differences in the means of pH values, which were at their greatest between the reindeer from southern, central and northern Lapland (Fig. 4). In northern Lapland the mean pH values in meat from calves in November was 6.03 but in December 6.22. In southern Lapland the steepest increase in the means for different months did not arise until between December and January. The mean for calf meat in December was 5.99 and in January 6.29. In January the total proportion of DFD carcasses did not increase, although the proportion of carcasses with very high pH did. In February the total percentage of DFD carcasses had risen to nearly 100 %. Half of the carcasses had a pH value of over 6.4. In March the percentage of DFD carcasses was 100 %.

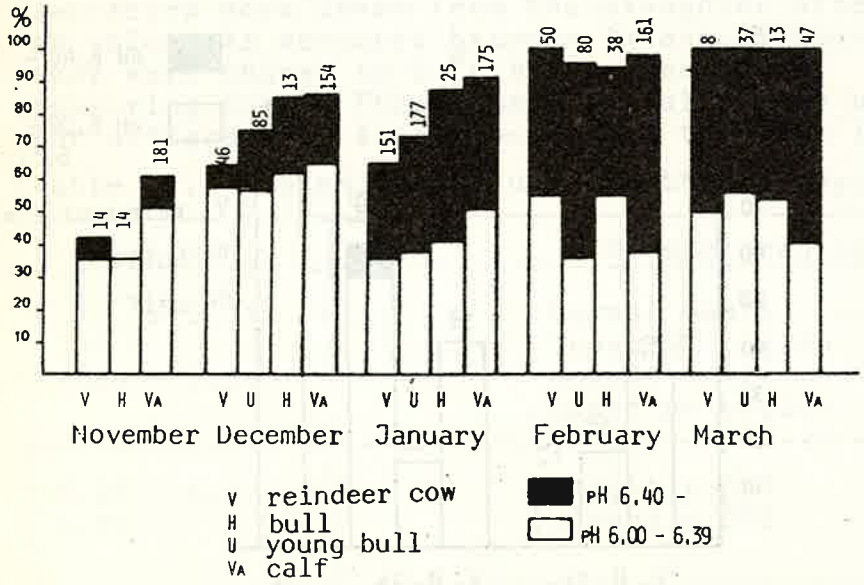

Fig. 3. DFD meat in reindeer from northern Lapland in different months

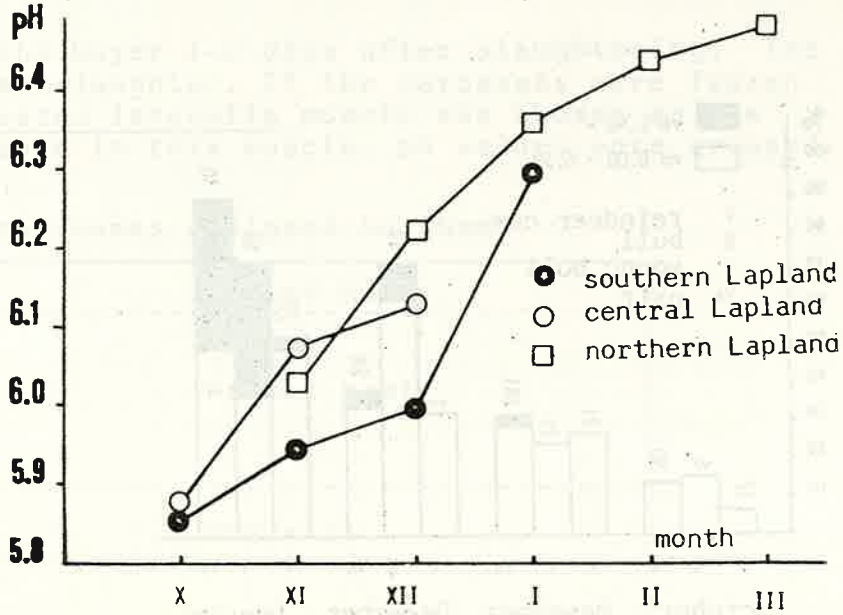

Fig. 4. The mean pH values of calves from southern, central and northern Lapland in different months.

DFD MEAT IN DIFFERENT MUSCLES

The pH values in the Vastus lateralis (knuckle) and Triceps branchi (shoulder) muscles proved *the highest of all.* The highest pH value appeared most regularly in knuckle and this part of the carcass was chosen as the measuring point when determining whether or not the carcass contained DFD meat.

In beef the highest pH values appeared in the Longissimus dorsi muscle (outer fillet) (Puolanne et al. 1981). The knuckle and the shoulder did not have high pH values in beef. It is unfortunate that the knuckle and shoulder are easily prone to DFD meat, because cold smoked reindeer meat made from the round and shoulder would fetch a higher price as a cold smoked product than as any other kind of product. In reindeer, the DFD meat in fillet is not as detrimental as it is in the Vastus lateralis and Triceps branchi muscles.

EFFECT OF PRE-SLAUGHTER HANDLING AND POST MORTEM CONDITIONS ON THE INCIDENCE OF DFD MEAT

The aim was to investigate the incidence of DFD meat by measuring pH values and biochemical parameters when reindeer were handled in different ways before slaughter. We compared reindeer handled normally with reindeer which had been removed past the slaughtering fence to rest and straight to slaughter. In the investigation the incidence of DFD meat in the 5 reindeer slaughtered first and in the 5 reindeer slaughtered last was compared.

The effects of post mortem conditions on the incidence of DFD meat were also investigated. The effects of rapid cooling of the carcass, rapid freezing and long-term cold storage on the decrease in pH and on the content of lactic acid, glycogen, glucose and ATP were studied.

Experimental procedure at places of slaughter

During the slaughtering season the aim was to visit one big and one small slaughter place in southern, central and northern Lapland each month. This was not completely successful. We received material from 17 places of slaughter; 15 reindeer were chosen for experimentation from each place. We tried to sample calves, cows, bulls and young bulls. When the reindeer herd arrived at the fencing pen, five reindeer were removed to an empty pen in which they were allowed to rest and become calm. They were also fed with hay and lichen. These reindeer were slaughtered separately from the others. When the actual slaughtering began, the first five animals and the last five animals were taken from the killing corral as sample groups. The pH values of the carcasses were measured at Poro and Riista Ltd. 24-48 hours after slaughter.

The Vastus lateralis muscle samples for glycogen, glucose, lactic acid and ATP determinations were taken from warm carcasses and after 24-48 hours. Reindeer from three places of slaughter were frozen and samples were taken after 3 and 6 months of cold storage. Blood samples were taken from all the experimental animals for CPK determination.

pH value in reindeer meat when animals were handled in different ways

Experimental slaughterings were devided into two groups according to the month of slaughter: October-November and December-February. The lowest pH value was found in those reindeer that were first rested and then slaughtered separately. In calves this was most distinct in winter: in calves from the experimental pen the mean pH value was 6.13, but in calves slaughtered first from the slaughter corral it was 6.42 and in carcasses slaughtered last from the slaughter corral the mean was 6.46. In autumn the respective values were 5.81, 6.03 and 5.98.

In reindeer cows the differences between the mean pH values of reindeer from the experimental pen and from normal slaughter corrals were small: the means differed by only 0.13-0.14 pH units. The mean pH values of reindeer cows from the experimental pens were the lowest, (5.79 in autumn and 6.03 in winter).

Table 2. Effect of season and handling of the reindeer on the mean of pH value in different types of reindeer.

	calf		reindeer cow		bull		young bull	
	pH	N	pH	N	pH	N	pH	N
Oct.-Nov.								
K	5,81	9	5,79	6	5,80	5		
T	6,03	7	5,90	9	5,90	1		
T_L	5,98	5	5,93	9	5,73	1		
Dec.-Febr.								
K	6,13	11	6,03	2	6,35	2	6,38	18
T	6,42	14	6,08	9	6,42	6	6,21	16
T_L	6,46	29	6,16	13	6,38	3	6,22	13

K = Experimental corral, 5 experimental reindeer, held in separate pen
T = 5 reindeer slaughtered first from slaughtereing pen
T_L = 5 reindeer slaughtered last from slaughtering pen
N = number of reindeer

The results show that most of the reindeer which had not been in the slaughtering corral had lower pH values than the reindeer which had. The reindeer from the experimental pen had less DFD meat. However, the difference between the two groups of reindeer was surprisingly small; the handling of the reindeer had no statistically significant effect on the pH value of the carcass when the material comprised all experimental reindeer. Instead, the effect of season on the pH value of the reindeer meat and thus on the incidence of DFD meat proved very significant ($p < 0.01$; analysis of variance). This was shown by comparing the autumn and winter slaughterings in two groups, and also by comparing all slaughterings. The combined effect of mode of handling and slaughtering was also highly significant ($p < 0.01$; analysis of variance), as was the combined effect of the time of year, mode of handling and the age and sex of the animals.

The lactic acid, glycogen and glucose contents in reindeer handled in different ways

The glycogen contants measured were very small, under 1.7 mg/g. In cattle the normal live glycogen content is 10-15 mg/g. We found no information about the glycogen content of live reindeer, but it is possibly at least about 10 mg/g. We tested the reliability of the method used with known concentrations of starch and found that the method gave the correct values.

The reason for the low post mortem glucogen contents is too long a time between stunning and the moment when the sample is completely frozen (at least 3 h). The majority of the glycogen was converted to lactic acid before the sample became frozen. The lactic acid contents are higher than the glycogen contents, being between 3.0 and 8.5 mg/g.

The glycogen and lactic acid contents are a little higher in the autumn than in winter. The reindeer removed to the experimental pens before slaughter had higher lactic acid and sugar (glucose) contents than reindeer slaughtered first from the slaughtering corral and especially those slaughtered last from the slaughtering corral. The pH values of the experimental animals are correspondingly smaller. The season and time of slaughter significantly affected ($p < 0.01$; analysis of variance) the content of lactic acid determined one day after slaughter. The combined effect of season, handling before slaughter and type of animal was also significant.

The sum of lactic acid, glycogen and glucose in this investigation best reflects the content of glycogen at the moment of slaughter. In autumn this sum changes from 7.5 mg/g to 10 mg/g and in winter from 4 mg/g to 7 mg/g.

Creatine phosphokinase (CPK)

When the animal is subjected to stress, creatine phosphokinase is liberated into the blood. To find the degree of stress, blood samples were taken for CPK determination from all 15 reindeer at each slaughter place. In winter, the blood CPK content was higher in all animal

types except young bulls than in animals slaughtered in autumn. In winter the mean CPK values were nearly 900 IU, being over 1000 IU in calves. In autumn, the respective figures were under 600 and 800 IU. Although the effect of season and handling of animals on CPK value was not significant, both factors together affected the CPK value to an extent of 93.8 %.

Effect of fast freezing and cold storing on the pH value and lactic acid, glycogen, glucose, and ATP content of reindeer meat

The mean pH values of reindeer carcasses were lower in reindeer salughtered in autumn (pH 6.26-6.47) than in reindeer slaughtered in winter. However, the corresponding differences in the contents of lactic acid, glycogen and glucose were not to be seen. Cold storage lasting several months increased the average pH value of reindeer meat a little, by about 0.05 units in three months and 0.07 units in six months. However, the increase is so small that it is probably an unreliable result.

Glycogen stores were already very small (1-3 mg/g) in samples taken from carcasses immediately after slaughter; the reason for this was too slow a freezing process. The lactic acid contents were respectively higher in recently slaughtered carcasses, being 3-4 mg/g and 5-7 mg/g one day after slaughter. The higher content in the one-day-old sample, despite the sample being frozen, is due to the thawing of the sample at the beginning of the determination, followed by glycolysis.

The glucose content usually decreased during cold storage. The mean glucose contents one day after slaughter in autumn were about 1 mg/g and in winter 0.5-0.8 mg/g, the contents usually decreasing during cold storage. The mean ATP contents after slaughter were about 1 g/100 g in autumn-winter and 0.4-0.7 g/100 g in winter. One day after slaughtering the ATP values had decreased. During cold storage, the ATP contents decreased in all reindeer groups, the degree of reduction, however, varying considerably.

SUMMARY

The incidnece of DFD meat in different autumn and winter months in different areas (northern, central and southern Lapland) was elucidated. The effect of different conditions and handling methods (exertion and stress) on the development of DFD meat was also investigated.
A study was also done to find out in which part of the carcass the DFD meat most easily appeared. Glycolysis was followed when the carcasses were cooled and frozen rapidly.
The most important results were:

1. The proportion of DFD carcasses (pH≥ 6.0) icreased steeply from autumn to January and further to March, when in practice all the carcasses had DFD meat. In January 80 % of the carcasses had DFD meat, and 40 % of all the carcasses had very high pH values (pH≥ 6.4). The mean pH value was over 6.3. In February the proportion of DFD carcasses was already nearly 100 %, reaching 100 % in March. The mean pH value was then about 6.5 and about half of the carcasses had high pH values (≥ 6.4).

2. In northern Lapland the number of DFD carcasses increased from December onwards, while in southern Lapland they began to increase from January onwards.
3. The highest amounts of DFD meat were found in reindeer calves. In young bulls and bulls, DFD meat appeared nearly as much as in calves, and clearly least in reindeer cows.
4. The handling of reindeer before slaughter had surprisingly little effect on the development of DFD meat, although the pH values of the carcasses of the animals penned separately were as a rule the lowest and the mean pH values of the animals slaughtered last the highest. However, the appearance of DFD meat was prevented most effectively by slaughtering the reindeer in autumn.
5. The highest pH values were measured in the knuckle and shoulder at all pH levels.
6. The rapid cooling and freezing did not prevent glycolysis, but the majority of the glycogen had changed to lactic acid before freezing.

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