SENSORY ANALYSIS OF MEAT FROM OLD CULLING EWES FED ON DIFFERENT LEVELS OF FISH MEAL

R. J. ANDERSEN[1], G. BERTELSEN[1], A. J. MØLLER[1], J. SAABY[1], and I. SKOVGAARD[2]

[1]Department of Dairy and Food Sciences, Royal Veterinary and Agricultural University, Howitzvej 11-13, DK-2000 Frederiksberg, Denmark.

[2]Department of Mathematics and Physics, Royal Veterinary and Agricultural University, Thorvaldsensvej 40, DK-1871 Frederiksberg, Denmark.

SUMMARY: In an attempt to reduce carcass fatness 16 old culling ewes from purebred Leicester and Oxforddown were fed on low energy diets (barley straws) supplemented with different levels of fish meal. The objective of the present study was to clarify whether the fish meal supplementation gave rise to fishy off-flavours as a result of oxidation of the unsaturated lipids during processing and/or storage. Sensory analyses were performed and the amounts of thiobarbituric acid reactive substances (TBARS) were measured from meat/fat blends in raw samples, heated samples (70°C), and 2-days stored, reheated samples. In addition lipid samples extracted from backfat of M. longissimus dorsi were analyzed for fatty acid composition. A trend towards increased off-flavour and decreased overall acceptability was found as a result of using fish meal in the diet. However, due to large variation between animals, mainly within the fish meal supplemented groups, no clear systematic effects were found. No significant effect of fish meal supplementation on any of the fatty acids were observed. This supports the general hypothesis that ruminants hydrogenate unsaturated lipids.

INTRODUCTION: Old culling ewes fetch low prices due to overfatness combined with the changes in consumer demand towards less fat in meat. Strong efforts have therefore been made with the objective of reducing fatness but retaining the meat content of the carcass. Vipond et al. (1989) have shown that it is possible to reduce fatness and retain the lean meat content of overfat lamb carcasses, if the lambs are fed daily on low-energy diets (barley straws) supplemented with 100 g of fish meal pellets, provided that the protein decomposition in the rumen is low.

It is generally accepted, that the body fat to a greater extent reflects the fatty acid composition of the diets for non-ruminants than for ruminants, as rumen bacteria hydrogenate polyunsatured fatty acids. It is also widely recognized that dietary inclusions of free oils can alter digestion in the rumen due to changes in activities of the rumen microbial population (Palmquist & Jenkins, 1980). Experiments have shown that, e.g., dietary substitution of naked oats for barley can alter ruminal digestion through effects that appear to derive from the associated increase in lipid intake (Martin, 1990).

Fish meal, however, includes fish oils characterized by very long, highly polyunsaturated carbon chains, is very sensitive for oxidation. It is therefore essential to investigate whether these compounds are transferred to the intramuscular and/or intermuscular fat, where they subsequently can produce unpalatable meat products, as a result of degradation of the unsaturated lipids during processing and/or storage giving rise to fishy off-flavours.

The objective of the present study was to establish if different levels of fish meal supplementation to barley straw diets gave rise to a fishy taste and increased amounts of thiobarbituric acid reactive substances (TBARS) in the meat from old culling ewes. Meat/fat mixtures were obtained from M. longissimus dorsi and the subcutaneous layer of backfat of old culling ewes from a control group and two groups fed on different levels of fish meal supplementation. The samples of meat/fat mixtures were heated to 70°C and subsequently stored for 2 days, after which they again were reheated to 70°C.

MATERIALS AND METHODS: **Animals and sampling.** Sixteen 4-6 year old culling ewes, purebred Leicester and Oxforddown, from a previous breeding experiment were used (Frederiksen et al., 1990). The animals were divided into three groups according to breed, age and live weight and fed on i) barley straw (group 0 = control), ii) barley straw plus 100 g fish meal (group 1), or iii) barley straw plus 300 g fish meal per day (group 2), respectively. The controls were slaughtered at the beginning of the trial, while the two experimental groups were fed for 14 weeks on the diets supplemented with fish meal before slaughtering. M. longissimus dorsi (11 - 13 th rib) was removed at 24 hr. post stunning and stored at - 20°C until further analysis.

Preparation of samples. The loin section was thawed at 2 - 4°C overnight and the lean meat and subcutaneous fat were finely comminuted in a Braun food processor. 10 gr. of comminuted meat were used for determination of total lipid and dry matter in the lean meat. The rest of the meat was weighed and mixed with 10% (w/w) comminuted subcutaneous fat and subsequently vacuum-packed and stored overnight at 2°C. The following day, meat/fat blends for sensory analysis were made by adding 50% water (w/w) to the standarized meat/fat mixture in 200 ml beakers and subsequently heated to a temperature of 70°C in a microwave oven (Philips Cooktronic M710). After the first organoleptic analysis the beakers were covered with oxygen permeable plastic film and stored 48 hrs. at 2°C. At day 2 the samples were reheated to 70°C in the microwave oven before the final sensory analysis.

Total lipid in lean meat. Total lipid of the M. longissimus dorsi was determined in duplicate according to the method of Salwin et al. (1955).

Fatty acid composition. Lipid samples extracted from the backfat of M. longissimus dorsi (single analysis) were analyzed for fatty acid composition using a chloroform-methanol procedure for lipid extraction (Bligh & Dyer, 1959) and a boron-trifluoride method for methylating (Metcalfe et al., 1966). The methylated fatty acids were separated by gas chromatography using a Perkin-Elmer Model 3920 with flame ionization detector and a coiled 3 m x 1/8" stainless steel column packed with 15% diethylene glycol succinate (DEGS) on chromosorb W HP 80/100. The column was run at 190°C (injection 0,5 µ1, N_2-flow 0,5 kg/cm^2, range 16 x 100). A known amount of an internal standard (C13:0) was injected with each sample. Quantitative values were determined by a Perkin-Elmer integrator SIP-1 and reported as percentage of fatty acids.

TBA test. The thiobarbituric acid (TBA) extraction method of Vyncke (1970, 1975) was used to measure oxidative rancidity (analysis in duplicate), and the TBA values were expressed as micromole malonaldehyde per kg meat sample. Dry matter was determined by drying the ground samples (raw, heated and reheated) to a constant weight in an incubator at 103°C (analysis in duplicate). Dry matter percentages were used for calculating TBA values.

Sensory evaluation. A 9 member taste panel was used for evaluation of meat taste, off-flavours and overall acceptance. A 10 point hedonic scale was used. For evaluation of meat taste and off-flavours: 9 = very strong meat taste/off-flavour and 0 = No meat taste/off-flavours. For evaluation of overall acceptability: 9 = very good and 0 = very bad.

Statical analysis. One-way analysis of variance was used to determine the effect of feeding group on TBA values, fatty acid composition, total lipid in lean meat and taste panel data. Bartlett's test was used for testing homogeneity of variance.

RESULTS & DISCUSSION: No significant difference in the content of intramuscular fat was found between controls and the two groups on fish meal supplementation. The mean values of total lipid in lean meat were 6.14%, 5.52% and 5.32% for group 0, 1 and 2, respectively.

Fatty acid composition. Results from the gas chromatographic separation of fatty acids from the backfat of M. longissimus dorsi are shown in Table 1. The C16, C18 and C18:1 revealed the largest standard deviation. However, no significant effect of fish meal supplementation on any of the fatty acids were observed. The C16 and C18 made up approximately 95% of the fatty acids determined and the extent of polyunsaturation (2 or more double bonds) was only about 2%. These results support the generally accepted view, that unsaturated fatty acids of the diet are hydrogenated by ruminants.

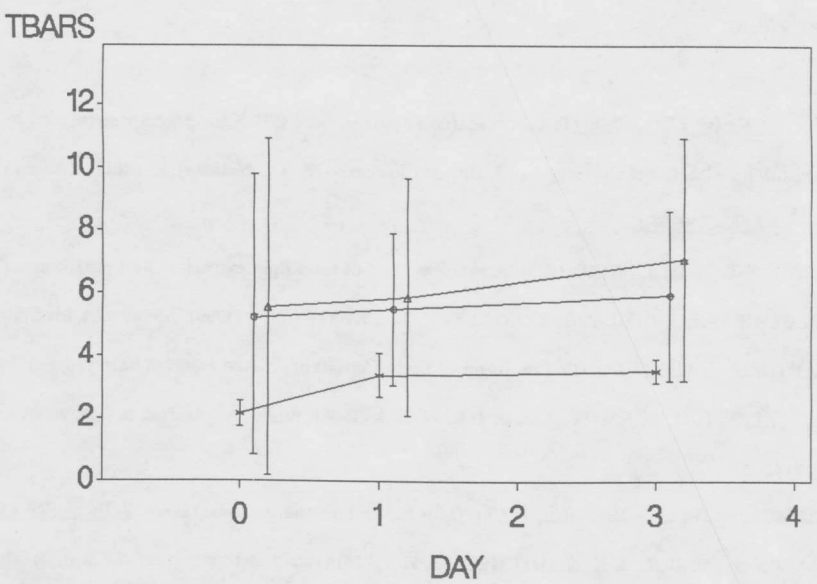
TABLE 1. Fatty acid composition of subcutaneous backfat of old culling ewes fed on different levels of fish meal in the diets. Group 0 = controls; Group 1 = 100 gr. of fish meal per day; Group 2 = 300 gr. of fish meal per day.

Fatty acids in %	Group 0 Mean ± SD[2)] (n = 5)	Group 1 Mean ± SD[2)] (n = 5)	Group 2 Mean ± SD[2)] (n = 6)	Signifi-cance
C10	0.11 ± 0.01	0.09 ± 0.02	0.10 ± 0.03	NS[1)]
C12	0.08 ± 0.03	0.07 ± 0.02	0.07 ± 0.01	NS[1)]
C14	2.96 ± 0.24	3.05 ± 0.36	2.89 ± 0.37	NS[1)]
C14:1	0.42 ± 0.08	0.34 ± 0.06	0.32 ± 0.06	NS[1)]
C15	0.18 ± 0.03	0.13 ± 0.04	0.16 ± 0.05	NS[1)]
C16	24.39 ± 1.03	23.17 ± 1.07	23.96 ± 2.23	NS[1)]
C16:1	1.60 ± 0.24	1.30 ± 0.37	1.45 ± 0.20	NS[1)]
C17	1.17 ± 0.23	1.17 ± 0.17	1.02 ± 0.10	NS[1)]
C17:1	0.60 ± 0.11	0.57 ± 0.22	0.55 ± 0.09	NS[1)]
C18	26.12 ± 3.78	28.43 ± 4.33	26.81 ± 4.52	NS[1)]
C18:1	40.06 ± 2.55	39.61 ± 3.88	40.35 ± 6.12	NS[1)]
C18:2	0.65 ± 0.19	0.49 ± 0.09	0.63 ± 0.13	NS[1)]
C18:3	1.50 ± 0.21	1.46 ± 0.24	1.49 ± 0.11	NS[1)]
Saturated	55.01	56.11	55.01	
Monounsaturated	42.68	41.82	42.67	
Polyunsaturated	2.15	1.95	2.12	

[1)] NS = NON SIGNIFICANT [2)] SD = Standard Deviation

TBARS. Results from TBARS measurements are illustrated in Fig. 1, which shows the mean values of TBARS by each feeding group as measured in raw, heated and re-heated samples. The TBARS level showed great variation among animals within the groups, and the standard deviation was apparently increased as a result of fish meal supplementation. The hypothesis of equal variances in the 3 groups was clearly rejected ($P<.001$).

Due to the large variances between animals in the two fish meal supplemented groups, no significant differences between mean TBARS levels were found. However, the increased variation was due to a few animals from each of the fish meal supplemented groups with high TBARS, whereas the rest of the animals were at the level of the control group.



Figur 1 Mean values with error bars (mean ± SD) of TBARS tests (in µmol malonaldehyde per kg sample) of meat/fat samples of old culling ewes fed different levels of fish meal. x-x, 0-0, ▲-▲ are referring to controls, 100g and 300 g respectively.

The tendency towards higher TBARS in meat from fish meal in the diet to sheep needs further studies.

Sensory analysis. Analysis of variance on sensory evaluations showed no significant differences between the feeding groups when one-way analysis of variance was performed at each time of measurement. However, as found for TBARS data, the assumption of homogeneity of variances for feeding groups had

to be rejected (P<.001). Mean values of sensory evaluations according to feeding group are shown in Table 2 as time of measurement was found insignificant. Apparently, the evaluation of off-flavour increased and corresponded to a decrease in overall acceptability, when increasing amounts of fish meal supplements were used in the diet. These results seem to be correlated with an increased TBARS value (Table 2), although none of the trends were significant.

In this study the TBARS values were not significantly increased by reheating. This result could be due to less non-heme iron - as a catalyst for autooxidation - had been released by microwave cooking as compared to conventional cooking.

TABLE 2. Mean values of sensory analysis and TBARS tests of heated and reheated meat/fat slabs to 70°C. Group 0 = controls; Group 1 = 100 gr. of fish meal per day; Group 2 = 300 gr. of fish meal per day.

	Group 0 Mean ± SD[2] (n = 5)	Group 1 Mean ± SD[2] (n = 5)	Group 2 Mean ± SD[2] (n = 6)	Significance
Meat Taste[3]	4.61 ± 0.40	4.23 ± 0.28	3.93 ± 0.80	NS[1]
Off-flavour[3]	1.45 ± 0.51	1.72 ± 0.76	2.40 ± 1.78	NS[1]
Overall Acceptability[3]	4.32 ± 0.46	3.91 ± 0.52	3.62 ± 1.12	NS[1]
TBARS Value. µmol/kg	3.47 ± 0.54	5.72 ± 2.43	6.48 ± 3.69	NS[1]

1) NS = NON SIGNIFICANT

2) SD = Standard Deviation

3) Scale = 0 - 9, with 9 being most intense in meat taste, off-flavour and highest overall acceptability.

CONCLUSIONS: The effect of fish meal supplementation in the diet for old culling ewes seemed to induce a higher proportion of animals with increased off-flavour and decreased acceptability of the meat after cooking. This resulted in an increased variation between animals compared to the control group without fish meal in the diet. This type of unsystematic variation makes the statistical results uncertain. Further studies are therefore needed to confirm these observations.

ACKNOWLEDGEMENT: This research is part of the FØTEK programme sponsored by the Danish Ministry of Education and Research. The authors wish to acknowledge Dr. J. Højland Frederiksen, The National Institute of Animal Science for providing samples for this study.

REFERENCES:

BLIGH, E. G. & W. J. DYER (1959): A rapid method of total lipid extraction and purification. Can. J. Biochem. Physiol. 37, 911.

FREDERIKSEN, J. HØJLAND, KRISTENSEN, H & SWGANA, N. (1990): Meddelelse fra Statens Husdyrbrugsforsøg (Da).

MARTIN, P. A. (1990): Digestion in Sheep of Diets Containing Naked Oats or Barley. J. Sci. Food Agric. 52, 477.

METCALFE, L. D., SCHMITZ, A. A. & J. R. PELKA (1966): Rapid proparation of fatty acid esters from lipids for gas chromatographic analysis. Anal. Chem. 38, 514.

PALMQUIST, D. L. & JENKINS, T. C. (1980): Fat in lactation rations: review. J. Dairy Sci. 63, 1.

SALWIN, H., BLOCH, I. K. & MITCHELL, J. H. (1955): Rapid Determination of Fat in Meat Products. Agricultural and Food Chemistry, 3, 588.

VIPOND, J. E. KING, M. E., ØRSKOV, E. R. & G. Z. WETHERILL (1989): Effects of fish meal supplementation on performance of overfat lambs fed on barley straw to reduce carcass fatness. Anim. Prod. 48, 131.

VYNCKE, W.: Determination of the thiobarbituric acid value in trinchloracetic acid extracts of fish as a measure of oxidative rancidity. WEFTA meeting September 1970.

VYNCKE,W. (1975): Evaluation of the direct thiobarbituric acid extraction method for determining oxidative rancidity in mackerel (Scomber scombrus L.). Fette Seifen, Anstrichmittel, 77, 239.