MUSCLE FIBRE CHARACTERISTICS AND TENDERNESS OF *M. LONGISSIMUS DORSI* OF ICELANDIC LAMB

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Background

The effects of muscle fibre types on meat quality have been extensively studied in pork and beef but not as much in lamb. Pigs highly bred for growth rate, effective feed conversion and high muscle content have much more of white, fast twitch, glycolytic fibres in their muscles (type II B) than wild boars. This has influenced both colour and rate of pH-fall after slaughter, final pH, drip and sensory characteristics of the meat and resulted in a poorer meat quality. (Lundstrom et.al., 1995). The distribution of fibre types and enzyme activity differ between breeds and genotypes(Essen-Gustavsson & Fjelkner-Modig.,1985). Meat of exercised pigs has been shown to be of a better quality than meat of non-exercised pigs. The meat was finer and had a higher tenderness and higher proportion of oxidative fibres. The connection between muscle fibre characteristics and tenderness of beef has been well documented but the results have been somewhat conflicting. Ashmore (1974) concluded that the change from oxidative to glycolytic fibres was good for meat quantity but not quality. Calkin et.al (1981) studied cattle of different levels of growth development and found a positive relationship between oxidative and a negative relationship between glycolytic fibres and tenderness. It is most often the type and level of feeding but not the fibre types that determine the tenderness of beef muscles (Vestergaard et. al 2000).

Training, exercise, grazing and free movement in the pasture increased the amount of oxidative fibres and decreased the amount of glycolytic fibres in lamb (Moody et.al,1980; Solomon & Lynch, 1988). This is thought to have a negative influence on meat tenderness. Exercise training of ram lambs increased both the amount of red fibres and toughness (Aalhus et.al.1991). Highland lambs often get both less energy and poorer feeds than indoor fed lambs or lambs on concentrates. Combining grazing with increased feeding can increase the amount of glycogen (Pethnick and Rowe, 1996). R. Hawkins et.al. (1985) studied the influence of genotypes on muscle fibre development and found little difference. Oxidative fibres decreased and glycolytic fibres increased with age.

Meat tenderness is determined by a complex combination of production systems and treatment during and after slaughter. A production system includes a breed (or a genotype/phenotype within a breed), feeding regime and a slaughter age. An EU project (*The Fair CT96 1768 OVAX)* on the quality and composition of lamb meat from production systems in six European countries was carried out in 1997-1999. Differences were found between types in tenderness and juiciness (Fisher, et.al 1999). Similar differences were found in instrumental texture. The differences can to some extent be explained by differences in age at slaughter and the amount of collagen (Berge, P. et. al , 2000; Sanudo et.al 2000). The Icelandic meat had a high tenderness associated with low score for juiciness that could be partly explained by age at slaughter but other factors in the production system like feeding regime, level of physical exercise could also have had an influence.

Objectives

The aim of the research was to clarify the effects of phenotypes within the Icelandic sheep breed, sex and production system on muscle fibre characteristics of *m. longissimus dorsi* and on quality characteristics like pH, glycogen level, intramuscular fat , total collagen and tenderness.

Methods

48 lambs of the Icelandic sheep breed were in the research. They were of two phenotypes, that is horned and polled. The carcasses of the polled lambs usually have a better conformation and higher fat score than the carcasses of the horned lambs. There were two equal subgroups of ewes and rams of each phenotype. The lambs were equally divided between two feeding regimes. The first group grazed with their mother ewes on upland flora in the open highlands were they were free to move within an extensive area. The lambs were slaughtered at the age of 4-5 months when they were gathered from the mountains in the end of September. The other group grazed with their mother ewes in a fenced lowland area on cultivated grass and concentrates. It was slaughtered 3 weeks later than the upland group.

Samples for muscle fibre and glycogen analysis were cut from the left side of the carcass from the *m. lomgissimus lumborum* just behind the last rib. They were stained for myosin ATP-ase activity (Brooke and Kaiser, 1970) at pH 4,3, 4,6 and 10,3. It was not possible to separate type II into types IIA and IIB by also using pH 4,6 so type II was separated into oxidative and nonoxidative fibres by staining for NADH-TR activity (Novikoff et.al1961 , Suzuki and Cassens 1983).

pH_1 and pH_{24} were determined in the open surface of the muscle. The M. *longissimus lumborum* from the right side of the carcass was used for sensory analysis. It was vacuum packed and aged at 2°C for six days before freezing at –24°C. Muscle *longissimus thoracis* was used for collagen and fat analysis. Samples for sensory analysis were thawed overnight at 2-4°C. They were grilled in an oven to a core temperature of 68°C. A trained taste panel assessed them. The panellists used a line scale from 0-100 to give scores for different sensory attributes. One-way analysis of variance was used on slaughter data and two-way analysis of variance on the data from the sensory analysis with treatment as a fixed factor and panellist as a random factor. Principal component analysis was used to see how different treatments influenced the distribution of the data and how different measurements were related.

Results and discussion

There was a highly significant difference in tenderness between production systems (feeding regimes). The meat of the upland lambs more tender than the meat of the lowland lambs. The upland lambs had about 1,5 kg lower carcass weight, higher pH_1 and lower pH_{24}, more glycogen, and higher proportion of oxidative fibres and a lower proportion of nonoxidative fibres. Using principal component analysis on the data showed that the first principal component explained about 39% of the variation in the data with type II oxidative and tenderness and the upland lambs being on the opposite end of the scale to type II(nonoxidative), toughness, lowland lambs and carcass weight. There was no difference in fat and collagen content. The groups differed mainly in age at slaughter, level of physical exercise and the upland lambs grazed on fields of somewhat higher energy levels and better nutritional quality. This confirms the results of former studies. Glycolytic fibres increase and oxidative decrease with age. (Hawkins et.al.1985). Physical exercise increases the level of oxidative fibres (Aalhus el.al.1991; Moody et.al,1980; Solomon & Lynch, 1988). But the difference in tenderness also indicates that quality of the grazing land was good. There was a significant difference in fat content and collagen content between phenotype groups. The polled lambs that had higher fat and collagen in the muscle and it showed a tendency towards more tenderness than in the horned lamb. There was no difference in fibre types, but the glycogen level was higher in the polled lambs. Ram lambs had a higher pH_{24} and lower collagen content than ewe lambs.

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Table 1. The effects of sex of lambs, phenotypes and production system (feeding regime, age at slaughter) on composition and tenderness of *m. longissimus dorsi*

	Sex of lambs		p	Genotype		p	Production system		p
	Ram	Ewe		Horned	Polled		Lowland	Upland	
Age at slaughter, days	146	147	0,58	143	149	0,01	155	137	0.001
Carcass weight, kg	15.0	16.5	0.02	15.8	15.8	0.90	16.7	14.8	0.002
pH_1	6.70	6.70	0.22	6.70	6.70	0.95	6.60	6.80	0.02
pH_{24}	5.58	5.64	0,02	5.60	5.60	0.41	5.7	5.70	0.002
% fat in muscle	2.53	2.30	0.30	2.13	2.71	0.02	2.39	2.44	0.76
% total , collagen	0.68	0.79	0.02	0.68	0.80	0.02	0.73	0.75	0.60
mg glycogen/ kg dry weight	204	211	0.60	191	224	0.06	192	224	0.06
% type I (oxidative)	6.51	6.51	0.91	6.20	6.86	0.22	6.01	7.01	0.07
% type I-II (intermediate)	0.96	1.59	0.16	1.48	1.07	0.33	1.43	1.12	0.44
% type II (oxidative)	64.3	62.0	0.11	62.9	63.2	0.82	61.4	64.8	0.02
% type II (nonoxidative)	28.2	30.0	0.22	29.4	28.9	0.82	31.2	27.0	0.001
Score for tenderness	51.3	53.3	0.39	50.5	54.3	0.08	48.3	56,6	0.000