INSTRUMENTAL TOUGHNESS OF LAMB FROM DIVERSE EUROPEAN SHEEP TYPES

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BACKGROUND

Meat texture is particularly related to myofibrillar and connective tissues. Muscle fibre characteristics can be evaluated by their sarcomere length and using low mechanical strains in raw meat (compression 20%) and collagen can be assessed at higher strains (compression 80%) (Lepetit, 1991). pH is also an important factor which determines meat texture (Devine et al., 1993). In contrast, Warner-Bratzler shear force (WBSF) has been widely used to evaluate meat tenderness. Although very variable relationships with sensory scores have been reported (Cover et al., 1962), it can be considered as a parameter related to both myofibrillar (Cross et al., 1973) and collagen (Young and Braggings, 1993) toughness. Also, texture is influenced by several factors such: productive, intrinsic, pre and post slaughter. Generally these factors have not been studied separately (Sañudo et al., 1998). The study of a large number of commercial lambs could help to evaluate the influence of some of these effects in the context of the lamb market.

OBJECTIVES

Our aim was to study the variations in meat toughness from a wide range of European commercial sheep types and relate these variations to characteristics such: breed, sex, age, weight at slaughter and feeding system.

MATERIALS AND METHODS

Lamb meat : Twenty two European lamb types were obtained from 6 countries. The description of these types is shown in Table 1. Lambs were slaughtered locally and the carcasses were held for 6 h at 10°C then chilled for 24 h at 2 (±2)°C. The *longissimus lumborum* (LL) from the left side of the carcasses was excised, vacuum-packed and aged for 6 days at 2 (±2)°C prior to freezing at –20°C.

Analysis: -pH: was measured 24 hours post-mortem using a penetrating glass electrode. Frozen loins were thawed in water for 2 h. and **two kinds of samples** (1 cm^2 cross-section following muscle fibres direction) were obtained: -1) raw meat for **compression test**. Twenty samples per lamb type were analysed across the main fibre axis using an Instron. The stress values at strains of 20 and 80% of initial sample thickness were recorded. Cell speed was 150 mm/min. -2) cooked meat (water bath to 70°C internal temperature) for **Warner-Bratzler**. One hundred and ten samples per lamb type were measured. Maximum load was determined. **-Sarcomere length**: was measured in non compressed sections of 20 of the samples of each lamb type used in the compression test. It was determined under microscope by optical examination of muscle sections fixed in glutaraldehyde.

Statistics: Data were subjected to ANOVA analysis and Scheffe´s test used to identify differences between treatments (lamb type).

RESULTS AND DISCUSSION

Significant differences were found ($p<0.001$) between lamb types in all the studied parameters (Table1).

pH mean values ranged between 5.44 and 5.84, they could be considered as normal in lamb meat. No relation between pH and age, sex or production system can be established, which agrees with the idea that pre slaughter or slaughtering effects could have been more important on this trait than intrinsic or productive ones. Devine et al. (1993) found that in this pH range (5.4 to 5.8) the higher the pH, the higher the WBSF. But this is not true in our case, probably because we compared very different animals and other muscle parameters could have more importance than pH itself.

Sarcomere length (SL) was between 1.46 and 1.77 μm. These values are bellow those reported in the literature in long ageing periods (Wheeler and Koohmaraie 1994), different measuring techniques and the fact that our samples were measured after freezing, could explain the differences. Age, weight, sex or production system do not seem to be related with SL but, some breed or country effect could be indicated. Thus, 3 of the 4 shortest SL belong to Italian breeds (Bergamasca and Appenninica, which has Bergamasca blood) and the four Icelandic types are among the 9 types with the longest SL. Thus, a relation between SL and WBSF could be established, although not in all the cases: the shorter the SL, the tougher the meat and vice versa.

Stress 20% (S20) was significantly higher in the youngest lamb types. As S20 rate is related with meat ageing, we could consider that this very young animals (<1.5 months old) have a weak enzymatic equipment to tenderize meat. The highest S20 values were not related with SL or WB results, which implies that these are virtually independent of low compression rates.

Stress 80% (S80) ranged between 44.60 and 66.93 N/cm^2. It has been demonstrated that the variations of S80 are mainly determined by differences in total collagen content. The Karagouniko lambs presented 3 of the 4 highest values and Icelandic lambs 3 of the 4 lowest values. Actually, high and low collagen contents were found in these 2 breeds respectively (Berge et al., 2000). On the other hand, it is accepted that toughness increases with age but, it is also true that the age effect on lamb tenderness is relatively small (Devine et al., 1993; Vergara et al., 1999) or it does not exist.

Warner Bratzler values were between 1.72 and 4.17 kg, which represents quite tender and aged meat (Wheeler and Koohmaraie, 1994). WBSF was higher in Italian lambs (the 4 types presented the 4 toughest meat), Karagouniko 3 months old and Churra milk

lambs. The lowest values were found in Icelandic lambs (3 of the 4 studied types were inside the 6 most tender meat), together with Merino and both Welsh Mountain types (5 and 6 months old). This could mean that production system and age are not the main criteria to explain lamb meat toughness. Thus, Rhodes (1971) found more differences by breed (Finnish short tail breed, related to Icelandic, were more tender than Suffolk) than by production system (Sañudo et al., 1998).

Table 1: Description of lamb types and texture analysis: Warner- Bratzler test on cooked meat (n=110 per lamb type), **pH, Compression test on raw meat and sarcomere length** (n=20 per lamb type).

DESCRIPTION						pH	WARNER-BRATZLER	COMPRESSION TEST		SARCOMERE LENGTH
Country[1]	Breed	Sex[2]	Age months	Carcass Weight kg	Feeding system		Max. Load kg	Stress 20% N/cm²	Stress 80% N/cm²	µm
GB	Suffolk*Mule	CM	4.0	17.8	Milk + Grass	5.59 abcd	2.95 defgh	5.28 a	45.28 a	1.547 ab
GB	Welsh Mountain	M	7.4	15.3	Grass	5.67 cd	2.16 abc	5.40 a	54.88 abc	1.562 ab
ES	Rasa Aragonesa	M	2.8	10.0	Concentrate	5.56 abcd	2.43 abcde	7.08 ab	58.35 abc	1.598 abc
ES	Churra	M	1.0	5.4	Milk	5.57 abcd	3.15 efgh	11.79 c	52.84 abc	1.526 ab
FR	Texel, Ile de France, Charolais	F	7.0	16.6	Grass	5.44 a	2.54 bcde	5.16 a	50.65 abc	1.600 abc
FR	Lacaune	F	3.3	15.3	Concentrate	5.45 a	2.24 abcde	5.75 a	52.40 abc	1.552 ab
GR	Karagouniko	M	1.7	8.1	Milk	5.84 e	2.86 bcdefg	10.59 bc	66.93 c	1.628 abc
GR	Karagouniko	M	3.5	15.4	Concentrate + Grass	5.61 bcd	2.44 abcde	5.68 a	66.52 bc	1.528 ab
IS	Icelandic	M	4.3	16.7	Milk + Grass	5.59 abcd	1.75 a	5.17 a	54.37 abc	1.718 bc
IC	Icelandic	F	4.3	15.9	Milk + Grass	5.55 abcd	1.72 a	5.02 a	45.59 a	1.648 abc
IT	Bergamasca	CM	12.0	30.5	Grass	5.64 bcd	3.98 ij	4.94 a	58.36 abc	1.474 a
IT	Appenninica	M	2.4	11.2	Milk + Concentrate	5.70 de	3.65 hij	7.17 ab	48.46 abc	1.466 a
GB	Welsh Mountain	M	5.0	10.4	Grass	5.63 bcd	2.29 abcd	5.24 a	49.30 abc	1.676 bc
GB	Suffolk*Mule	CM	7.4	20.5	Concentrate	5.58 abcd	2.76 bcdef	5.24 a	44.60 a	1.678 bc
ES	Merino	M	3.0	13.6	Concentrate	5.51 ab	2.14 abc	4.82 a	48.33 abc	1.679 bc
ES	Manchega	M	3.0	11.8	Concentrate	5.57 abcd	3.33 fghi	7.59 ab	51.13 abc	1.646 abc
GR	Karagouniko	CM	5.1	14.0	Grass	5.55 abcd	2.88 cdefg	4.96 a	57.34 abc	1.607 abc
GR	Karagouniko	CM	2.3	11.1	Concentrate	5.61 bcd	3.56 ghij	4.67 a	47.47 ab	1.561 ab
IS	Icelandic	M+F	2.7	13.9	Milk + Grass	5.53 abc	2.11 ab	4.21 a	45.18 a	1.651 abc
IS	Icelandic	M	7.0	16.5	Grass	5.58 abcd	2.81 bcdefg	4.76 a	45.60 a	1.642 abc
IT	Bergamasca	M	6.0	18.9	Grass	5.69 d	4.13 j	4.73 a	53.52 abc	1.770 c
IT	Bergamasca	M	5.0	19.7	Concentrate	5.58 abcd	4.17 j	6.13 a	48.77 abc	1.528 ab
Std.	-	-	-	-	-	0.42	1.21	3.20	13.91	0.13
F	-	-	-	-	-	10.21	63.22	18.69	8.85	10.32
Sig.	-	-	-	-	-	***	***	***	***	***

[1] GB: Great Britain, ES: Spain, FR: France, GR: Greece, IS: Iceland, IT: Italy.
[2] M: Male, CM: Castrated male, F: Female.

*** p<0.001 For measurement, values with different letters are significantly different.

ONCLUSION

When very different commercial lamb types are compared, meat toughness differences seem to be more related with breed or, to a ower extent, with age than with production system. Some efforts to analyse interactions between these main effects should be done.

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