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VARIATIONS OF MEAT COMPOSITION AND QUALITY IN DIFFERENT COMMERCIAL LAMB TYPES

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BACKGROUND AND OBJECTIVES

As for many other types of meat, lamb shows large variations in eating quality that are perceptible by the consumer, e.g. in flavour, colour, texture and juiciness. It is well established that in the first instance these variations are attributable to the combined effects of several *ante mortem* factors such as sex, breed, age, feeding regime. *Post mortem* factors such as the chilling conditions also have a major influence on lamb quality. Sex influences the rate of fat deposition in the carcass tissues and it determines the deposition of specific compounds responsible for the occurrence of mutton flavour (Young et al., 1998). However, sex differences are generally small since lambs are generally slaughtered at an early stage of development (Sañudo et al., 1998a). For the same reason the effects of breed are small and can be explained easily by differences in maturity (Vesely and Peters, 1966; Bray, 1988; Dransfield et al., 1990; Dufey and Wirz, 1995a; Sañudo et al., 1998a). As lamb age increases, the meat exhibits a more intense colour, a lower tenderness and a stronger flavour (Bruwer et al., 1987; Bray, 1988; Schönfeldt et al., 1993; Young et al., 1993). Both feeding level and type of food influence the amount and the composition of tissue lipids, and consequently meat flavour (Sink and Caporaso, 1977; Young et al., 1998). The respective effects of *ante mortem* factors on lamb quality have been investigated extensively in the past. In contrast, few results have been published that allow an objective comparison of the different lamb meats produced in different regions of the world. Significant differences in texture and flavour scores among commercial lambs from Spain, Great-Britain, Switzerland, Canada, New Zealand and Australia have been reported by Jeremiah (1988), Dufey and Wirz (1995b) and Sañudo et al. (1998b). The objective of the present work was to study variations in the texture of meat obtained from contrasted European lamb types and to relate these variations to animal age and to muscle composition. It is part of a collaborative research project (FAIR 3CT96-1768) supported by the European Union and including six European countries which supplied the animals (see footnote for contact persons). The first part of this study was reported earlier by Berge et al. (1998).

MATERIALS AND METHODS

Six commercial lambs types, each including 20 animals, from different European countries were studied. Within each type, lambs had the same sex status and feeding background, and similar age, breed type and carcass weight. The breed types differed between countries and included dairy and meat breeds. Lambs were fed milk (1 type), or milk supplemented with concentrate (1 type), or they were weaned and subsequently fed concentrate either alone (1 type) or supplemented with hay (1 type), or raised on pasture without supplement (2 types). Four types consisted of ram lambs and the two others of female lambs. Each lamb type was slaughtered in its country of origin. The carcass was kept for 6 h post mortem at room temperature (> 10°C) prior to chilling for 24 h at 2 (± 2)°C. A sample of the *Longissimus thoracis* muscle was frozen at –20°C until determination of its chemical composition (moisture, total collagen, soluble collagen after a 90°C, 2-h heat treatment, lipids, pigment). A sample of the *Longissimus lumborum* muscle was vacuum packed, aged for 6 days at 2°C and frozen at –20°C. After thawing, this sample was used for the determination of sarcomere length (10 lambs/type) and texture. A raw subsample was submitted to a compression test across the main muscle fibre axis using an Instron universal testing machine. The stress values at strains of 20 (S-20) and 80 % and 80 % (S-80) of initial sample thickness were recorded. Another subsample was cooked at 75°C until a 70°C internal temperature was reached. Then, a Warner-Bratzler (WB) shear test was performed, and the maximum stress and average stress were determined. Another sample of the *Longissimus lumborum* was grilled to 67°C internal temperature and submited to a sensory analysis by 10 trained panelists during 18 sessions.

RESULTS AND DISCUSSION

The individual age of the lambs ranged from approximately 1.0 to 8.1 months. The ages were on average around 1.0, 2.4 (± 0.3), 3.3 (± 0.4), 3.5 (± 0.3), 4.3 (± 0.3) and 7.4 (± 0.5) months in the different lamb types. The respective average cold carcass weights were 5.4 (± 0.4), 11.2 (± 1.1), 15.3 (± 1.2), 15.4 (± 1.7), 15.9 (± 1.4) and 15.3 (± 1.1) kg. The muscle pigment content increased with lamb age ($r = 0.85$, $P < 0.001$; Figure 1) and it was on average 3.7 (± 1.0), 6.9 (± 1.2), 6.9 (± 0.9), 6.6 (± 0.6), 9.3 (± 1.2) and 10.4 (± 1.1) µg haem iron/mg respectively, thus confirming the trend reported by Berge et al. (1998) for six other lamb types. The individual intramuscular lipid contents ranged from 0.7 to 4.5 % with large variations within lamb type (24 to 45 % coefficient of variation). The two youngest lamb types showed lower lipid contents (mean values 1.5 and 1.7 %) compared with those of the older ones (mean values 2.4 to 3.0 %). The individual total intramuscular collagen content (hydroxyproline × 7.5) ranged from 2.5 to 6.6 mg/g (average 4.2 ± 0.9). On average by lamb type, it ranged from 3.2 to 5.0 mg/g. The youngest lamb type exhibited the second highest collagen content which confirms the findings by Young and Dobbie (1994) and Berge et al. (1998) that the collagen content in lambs of less than 1 month of age may be of

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the same order or even greater than in older lambs. The collagen heat solubility showed a marked and gradual decrease with increasing age from 49 % at 1.0 month to 27 % at 7.4 months of age (r = -0.78, P < 0.001; Figure 1) which is consistent with the results of Boccard et al. (1970), Young et al. (1993) and Berge et al. (1998).

As previously observed with other lamb types (Berge et al., 1998), the variations of meat texture were considerable between the six lamb types. The texture data are presented together with the other animal and composition data after PCA analysis (Figure 2). The toughness of the raw myofibrillar tissue (or S-20; Lepetit, 1989) after a 6-day ageing period was 12 N/cm² in the 1-month old lambs and significantly greater than in any of the other types (range 5.0 to 7.7 N/cm²; P < 0.001), thus showing that there were large differences between animals in the rate of muscle *post mortem* tenderization. A lower rate of tenderization could explain why those youngest lambs produced the second toughest loin meat. Indeed, their insoluble collagen content was the second lowest which shows that the high solubility of their collagen compensated for their high collagen content,. The connective tissue toughness in the raw meat (or S-80) was much less variable between lamb types (range 50 to 64 N/cm²). Surprisingly, the correlation between S-80 and the total collagen content (r = 0.30) was much lower than that found previously (r = 0.60; Berge et al., 1998). The cooked meat of the less tender lamb type was twice to three times tougher than that of the most tender type. The peak force and the average toughness ranged from 16 to 40 and from 7 to 15 N/cm² among the lamb types, respectively. The sensory evaluation of tenderness showed a relatively high correlation with the instrumental measurements of toughness (r = -0.60 and -0.56, respectively; P < 0.001). All texture measurements on cooked meat showed moderate or low correlation coefficients (around 0.32 and 0.10 respectively) with total and insoluble collagen contents, but their correlation with S-20 was generally higher (r = 0.36 to 0.60). Correlations between tenderness and either pHu value, lipid content or collagen solubility were low (r = -0.34, 0.33 and -0.21 respectively). Young and Braggins (1993) and Young et al. (1993) reported correlations of the same order, although slightly higher (around 0.34 to 0.43), between collagen solubility and texture measurements. These authors did not find any relationship between collagen content and instrumental texture measurements (r ≤ 0.20), but this was in contradiction with their finding of a 0.53 correlation between tenderness and collagen content. Only 12 to 16 % of the variations in the different texture measurements were accounted for by the variations in sarcomere length (range 1.43 to 1.73 μm). No noticeable relationship either was found between meat juiciness or flavour and any of the other measurements.

CONCLUSION

The present work confirms that considerable variations in the loin meat quality exist between European commercial lamb types even when the post-mortem conditions applied to the carcass are the same and when the meat is analysed in the same laboratory. These variations are the consequence of the differences in the combinations of breed, sex, age, feeding regime that define the production systems specific to the lamb types studied. The results confirm most of the conclusions of the first part of this study on European lamb types (Berge et al. 1998). The amount of connective tissue and the rate of *post mortem* tenderization were the major determinants of lamb texture while there was no apparent implication of collagen solubility, total lipids, ultimate pH value or sarcomere length.

Figure 1. Variations of pigment content (dotted line) and collagen solubility (solid line) in the loin muscle with lamb age

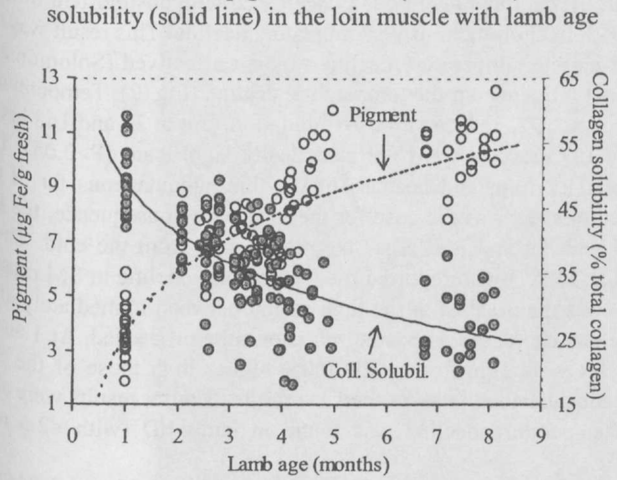
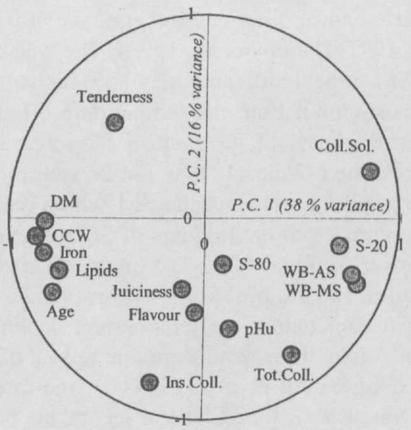


Figure 2. Principal component analysis of composition and texture of loin meat in contrasted lamb types



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