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Meat and fat quality of unweaned lambs as affected by slaughter weight and breed

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ABSTRACT

Sixty-four male lambs of two Southern Spanish breeds, a dairy breed (Grazalema Merino) and a meat breed (Churra Lebrijana), were used to study the effects of slaughter weight and breed on meat traits and intramuscular and subcutaneous fat composition. Lambs were reared following a traditional production system without weaning and slaughtered when live weight reached 12 kg (suckling) or 20 kg (light). Meat from suckling lambs of both breeds had lower fat and myoglobin contents, and was more tender and had higher scores for sustained juiciness in the sensory analysis. Fat from light lambs had lower C12:0 and C14:0 levels than fat from suckling lambs. Grazalema Merino meat had higher fat and ash contents, and its fat had higher conjugated linoleic acid content than Churra Lebrijana meat.

1. Introduction

Mediterranean consumers' preference is for lamb fed either milk or mainly concentrate diets (Sañudo et al., 2007). Light carcasses from young animals are preferred, fetching high prices, due to the pale pink color, reduced amount of fat and subtle flavor of their meat (Beriain et al., 2000; Castro, Manso, Mantecón, Guirao, & Jimeno, 2005). This is why the characteristics of lamb carcasses produced in European countries of the Mediterranean region are very specific and different from most other regions. Lambs are slaughtered very young, just after weaning (between 30 and 60 days) or after a short period of fattening.

Local breeds, such as Grazalema Merino (GM) and Churra Lebrijana (CL), located in Southern Spain, have traditionally produced lambs at two different slaughter weights, suckling and light lambs, following a production system based on ewes' milk. This non-weaning system is used to take advantage of ewes' milk and to avoid the stress due to weaning (Vernon, 1980). The first breed, GM, is a dairy sheep breed, with an estimated mature weight of 75–85 and 40–50 kg for males and females, respectively. Milk production by GM ewes is around 500 ml/day, with 9% fat (Molina et al., 2002). CL breed is a meat breed with estimated mature weight of 65–80 and 35–48 kg for males and females, respectively. Milk production by CL ewes is around 300 ml/day (Romero, 2007).

The traditional production system under which Mediterranean lambs from local breeds are raised would meet the consumer requirements. However, there is little information about the effect of these management systems on the meat quality of light lambs produced in Mediterranean areas (Santos-Silva, Bessa, & Santos-Silva, 2002). Therefore, the aim of this work was to study the quality traits of meat and fat from suckling and light lambs from two sheep breed types (dairy and meat) in their traditional production systems, without weaning.

2. Materials and methods

2.1. Animal management

Sixty-four male lambs from single birth litters were selected for the study. Sixteen animals of each breed were raised up to 12 kg live weight (suckling lambs slaughtered after weaning) and sixteen to 20 kg live weight (light lambs slaughtered after short period of fattening) (Table 1) using the same traditional system without weaning. Suckling lambs only consumed ewe milk. Light lambs were not weaned, but had access to concentrate *ad libitum* from 45 days after birth. Lambs were confined at all times and allowed to suckle when ewes were not grazing. The nutritional composition of the commercial concentrate (barley, corn and soya) consumed by lambs was 18% protein, 2.5% fat, 4% cellulose and 6.5% ash. The diet of the ewes was composed of local pastures when available and the same commercial concentrate (barley, corn and soya) (15.5% protein, 2.3% fat, 6.8% cellulose and 6.7% ash) and cereal straw was provided *ad libitum*. Both breeds were reared in the same area (southwestern Spain), therefore the composition and availability of pastures was similar for all the sheep.

The lambs were slaughtered in an EU accredited slaughterhouse. Carcasses were chilled at 4 °C for 24 h, weighed, and pH

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Table 1
Carcass trait mean values of Grazalema Merino (GM) and Churra Lebrijana (CL) suckling and light lambs.

	Suckling		Light		Breed (B)	Slaughter weight (W)	B × W	SEM
	GM (n = 16)	CL (n = 16)	GM (n = 16)	CL (n = 16)	Sig.	Sig.	Sig.	
Slaughter weight (kg)	11.40	11.41	20.84	20.17	NS	***	NS	0.266
Carcass weight (kg)	5.83	5.61	10.19	9.99	NS	***	NS	0.203
pH 24 h	5.61	5.60	5.64	5.66	NS	NS	NS	0.032
Fatness degree	1.90	1.13	2.65	2.58	**	**	*	0.121
SFT (cm)	1.23	0.57	1.35	0.71	**	NS	NS	0.205

Sig.: Significant differences; NS (non-significant): $P > 0.05$; SEM: standard error of mean; SFT: subcutaneous fat thickness. Fatness degree: 1 = 1−, 2 = 1 (very scarce), 3 = 1+, 4 = 2−, 5 = 2 (scarce), 6 = 2+, 7 = 3−, 8 = 3 (medium), 9 = 3+, 10 = 4−, 11 = 4 (important) and 12 = 4+.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

(pH 24 h) was measured in *longissimus dorsi* muscle with a penetrating glass electrode on a hand-held Crison pH/mv-506 meter. Degree of fatness (1-low; 4-high) was assessed by two trained assessors, using the EU photographic standards for carcasses under 13 kg effective in Spain (Reglamento CEE no. 461/93). Each level of the EU scale was divided in three sub-levels in order to discern small differences in the degree of fatness (1 = 1−, 2 = 1 [very scarce], 3 = 1+, 4 = 2−, 5 = 2 [scarce], 6 = 2+, 7 = 3−, 8 = 3 [medium], 9 = 3+, 10 = 4−, 11 = 4 [important] and 12 = 4+). Subcutaneous fat thickness (SFT) was measured with a digital callipers at the point of intersection located 4 cm from the spine and 4 cm behind the last rib of the left side of the carcass, according to the method of Boccard and Dumont (1955). Samples from subcutaneous (SC) fat were collected in the slaughterhouse within the first hour *post-mortem*, vacuum packed and frozen at −20 °C. For intramuscular (IM) fatty acid composition (*longissimus dorsi pars thoracis*, T3–T5), meat quality parameters (*longissimus dorsi pars thoracis*, T5–T13) and sensory analysis (*longissimus dorsi pars lumborum*), *longissimus dorsi* muscle samples were collected 24 h post-slaughter from the left side of carcasses, vacuum packed and aged at 2 °C for 72 h.

2.2. Meat quality parameters

After ageing for 72 h, total percentages of protein, moisture and ash were determined according to AOAC methods (AOAC, 1990). The protein content was measured by the block digestion method (UNE 55-020), the moisture content was determined by drying at 102 °C for 24 h (ISO R-1442) and ashing was determined by heating to 550 °C for 24 h (ISO R-936). Fat percent was measured according to the Soxhlet method (ISO R-1443) using a Foss Tecator AB Soxtec 2050 (Stable Microsystems, UK).

Water holding capacity (WHC) was determined by duplicate in fresh meat (5 g) following the method of Grau and Hamm (1953) and expressed as percentage of expelled water. Warner–Brätzler (WB) texture meat analysis was performed as in Campo et al. (2000). The samples (T10–T13) were cooked in a water bath at 75 °C until the internal temperature reached 70 °C, using a TA-XT2 texture analyzer (Stable Microsystems, UK). Samples (n = 5 per muscle) of 1 cm^2 on cross section were cut with muscle fibers parallel to the longitudinal axis of the sample. Shear force was assessed in warm meat using a WB device, shearing until breaking the samples.

CIE $L^*a^*b^*$ color coordinates were measured on the surface of *longissimus dorsi* muscle after cutting a slice and blooming for 1 h using a spectrophotometer Minolta CM-2500d. The L^*, a^* and b^* values were recorded using the standard illuminant D65 and 10° standard observer. Myoglobin (Mb) concentration in *longissimus dorsi* muscle was measured as described by Hornsey (1956), and expressed as mg Mb/g of fresh meat.

2.3. Fatty acid composition

Fatty acids of IM and SC fat depots were analyzed following the method described by Aldai, Osoro, Barron, and Nájera (2006), which has been reported to be highly effective for PUFA analysis (Juárez et al., 2008). Separation and quantification of the fatty acid methyl esters was carried out using a gas chromatograph (GC, Varian Star 3400CX, Varian Associates Inc., California, USA) equipped with a flame ionization detector and fitted with a BPX-70 capillary column (120 m, 0.25 mm i.d., 0.2 μm film thickness, SGE, Australia). Tricosanoic acid methyl ester (C23:0 ME) at 10 mg/ml was used as an internal standard. Individual fatty acids were identified by comparing their retention times with those of an authenticated standard fatty acid mix Supelco 37 (Sigma Chemical Co. Ltd., Poole, UK). Identification of the isomers of conjugated linoleic acid (CLA) *cis*9–*trans*11, *cis*11–*trans*13 and *trans*10–*cis*12 was achieved by comparing retention times with those of another authenticated standard mix (Sigma Chemical Co. Ltd., Poole, UK). Fatty acids were expressed as a percentage of total fatty acids identified and grouped as follows: saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA). PUFA/SFA ratio was calculated.

2.4. Sensory analysis

The samples designated for sensory analysis (whole *longissimus dorsi pars lumborum* aged for 72 h) were wrapped in aluminum foil, after removing external fat, and cooked at 200 °C in a double plate grill until the internal temperature reached 70 °C. Each cooked steak was trimmed of external fat, cut into 2 × 2 cm^2 samples and served warm to a 12 member trained taste panel. The panelists used a 10 point hedonic scale to evaluate the samples for tenderness (1-extremely tough, 10-extremely tender), initial and sustained juiciness (1-extremely dry, 10-extremely juicy), chewiness (1-non-chewy, 10-extremely chewy) and lamb flavor intensity (1-no aroma, 10-very intense) (AMSA, 1995).

2.5. Statistical analysis

The statistical analysis was performed using SPSS 12.0S for Windows (SPSS Inc., 2003). In the analysis of variance the breed and slaughter weight effects and the interaction between breed and slaughter weight were included. Single animals were considered as experimental units.

Linear correlations were calculated between lamb flavor and C18:0 and C18:2 fatty acid content in IM and SC fat depots.

3. Results and discussion

Breed had no effect on carcass weight and pH values (Table 1) of GM and CL lambs ($P > 0.05$). As expected, carcasses of heavier