FATTY ACID COMPOSITION OF LAMB MEAT FROM SPAIN, BRITAIN, GERMANY AND URUGUAY

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Background

The fatty acid composition of intramuscular fat can be influenced by factors such as diet (Rhee, 2000), breed (Robelin, 1986), age (Link et al., 1970) and the level of fatness of animals (Nürnberg et al., 1998). On the other hand, the fatty acid composition influences the nutritive value and the palatability of the meat. In relation to the nutritive value, consumption of saturated fatty acids (SFA) has been associated with an increase of plasma cholesterol and plasma low density lipoprotein levels, which are linked at the same time to a major risk of coronary heart disease. Conjugated linoleic acid (CLA), which arises from microbial hydrogenation of dietary linoleic acid in the rumen, exhibits anticarcinogenic properties when is included in the diet at low levels (French et al., 2000). Additionally, meat flavour is influenced by the saturation rate of fatty acids (Purchas et al., 1979). The polyunsaturated fatty acids (PUFA) are more susceptible to oxidation than monounsaturated fatty acids (MUFA), their oxidation is primarily responsible for the oxidative meat flavour deterioration (Gatellier et al,, 2001).

Objectives

The purpose of this study was to analyse fatty acid composition in commercial lamb types representing different production systems from Spain, German, United Kingdom and Uruguay to assess the extent of "natural" dissimilarity in their fatty acid composition.

Materials and methods

Five groups of 20 lambs slaughtered at usual commercial weight were used from four countries: Spain, United Kingdom, Germany and two types of Uruguay, heavy and light lambs, which are representative of their typical production system conditions. Spanish lambs were from Rasa Aragonesa breed, produced in an intensive-housed system, weaned and kept on concentrates and cereal straw *ad libitum* until slaughtering. The carcass weight was 10.2 ± 0.2 kg. British lambs were Dorset breed, mainly reared on a grass-based system, using strategic concentrate supplementation, being carcass weight 22.8 ±1.7 kg. German lambs were commercial lambs (crossbreed between Merino Landschaf x Suffolk or Schwarzköpfe); with a carcass weight of 23.2 ± 3.6 kg. They were reared on grass complemented with concentrate. Uruguayan lambs were from Corriedale breed, they were raised under extensive improved grazing conditions, producing two types of lambs; the carcass weight of light and heavy lambs were 11.1 ± 1.4 and 19.6 ± 2.2 kg., respectively.

Intramuscular fat was extracted from *longissimus lumborum* muscle (Hanson and Olley, 1963). Methyl esters of the samples were formed according to Morrison and Smith (1964), using nonadecanoic acid (19:0) prior to saponification as internal standard. Chromatographic analysis of methyl esters was performed using a Perkin-Elmer gas chromatograph (Perkin-Elmer, USA). Fatty acids were identified from standards and quantified using the internal standard.

One-way ANOVA was performed using GLM procedure from the Statistical Analysis System package (SAS, 1996). Differences between the means were determined using the Student-Newman-Keuls test. PRINCOMP procedure was used to principal component analysis, the variables were standardized.

Results and discussion

The least square means of the fatty acid composition (expressed as proportion by weight of total fatty acids) of the lambs and fatty acid ratios from typical production systems of the countries studied are shown in table 1 and 2, respectively. Spanish and Uruguayan light lambs showed the lowest intramuscular fat proportion (2.41% and 3.05%, respectively) related to the lowest weights and ages at slaughtered in comparison with the rest of the lamb types, where the Uruguayan heavy lambs had the highest intramuscular fat proportion (5.92%) with intermediate position to United Kingdom (4.32%) and German lambs (4.25%).

Spanish lambs showed the highest proportion of C18:2 and lowest of C18:0, while the Uruguayan and German lambs had the highest percentage of C16:0. The proportions of C18:3 and C20:5 were higher with grass fed lambs (mainly Uruguayan) compared with lambs reared intensively using concentrates (Spanish and German lambs). These differences in fatty acid composition could be mainly related to differences in the feeding production system (grass or concentrate). Thus, Díaz et al. (2002) found lambs fed with concentrate showed lower percentage of C18:0 and higher C18:2 than lambs fed with pasture. Grass contains high levels of C18:3, precursor of the *n*-3 fatty acids series, while concentrate generated high level of 18:2 precursor of *n*-6 fatty acids series (Rhee, 2000).

The CLA isomer, *cis-9, trans-11 18:2*, was detected in all the lambs types evaluated. However, Spanish lambs had only 0.40 % of the total of fatty acids, while the other lambs, showed more than twofold (0.94 % and 0.79 % for light and heavy Uruguayan lambs, 0.97 % for German and 1.05 % for British lambs). French et al. (2000) showed the linear increment of intramuscular CLA concentration when the proportion of concentrate in the diet decreased. The high concentrations of rapidly fermentable sugar and soluble fibre of forage creates a rumen conditions which promotes a greater production or decreased utilization of CLA by the rumen (Kelly et al., 1998).

The highest P/S ratio was for Spanish lambs, due to their lower proportion of SFA and higher of PUFA. It could be due to differences in feed, age and fatness level. Thus forage stimulates ruminal activity promoting the biohydrogenation of the fatty acids, which in turn, increases the concentration of SFA (Choi et al., 1997). Link et al. (1970) showed in muscle that the proportion of PUFA decreased with increasing animal age and concomitant increases in intramuscular neutral lipid deposition. The increment of SFA with age and decrement of PUFA could be the reason why older animals (German, British and Uruguayan heavy lambs) showed low PUFA proportions and P/S ratio. With regard to fatness Nürnberg et al. (1998) found a negative relationship between fat content and PUFA, and Marmer et al. (1984) found that triacylglycerols, which increased with fatness, are less unsaturated than phospholipids in muscle membranes. The ratio *n*-6/*n*-3 was very high in Spanish lambs (8.42) related to the other lambs (lower than 2.5). According to Kemp et al. (1981), the use of concentrate resulted in raised concentrations of *n*-6 PUFA and grass diets increased *n*-3 PUFA.

Principal component (PC) analysis was performed on intramuscular fat to study the relationship between fatty acid percentages and to examine the relationships between the types of lambs compared. Figure 1 displays the projection of the fatty acid data in the plane defined by the two first principal components (PC). The first PC explained 34.97 % of the variability of the fatty acid composition. This component was mainly characterized by C18:2, C20:4 in the right hand side and antithrombotic relation (ATT) in the left one; where these variables were placed far from the origin of the first PC. The second PC explained the 21.50 % of the variability, it was defined by long chain fatty acids (C22:5, C22:6 and C20:5) and in the opposite direction by MUFA, which were placed far from the origin of the second PC. However, Bas and Morand-Fehr (2001), using PCs analysis to study fatty acid composition, found that the first two PC explained about 45% of the total variance in subcutaneous and intramuscular fat, and about 60% in perirenal adipose tissue. The projection of the fatty acid data in the plane defined by the two first principal components of the five groups studied is shown in figure 2. Spanish lambs were clearly separated from rest of lamb types and were placed on the right hand, close to short chain fatty acids and *n*-6. The Uruguayan light lambs were located down in the figure, close to long chain fatty acids, whereas Uruguayan heavy and British lambs are slightly moved on the left side, where ATT, C18:0, SFA and CLA lay and German lambs were located between Spanish lambs and the other three groups.

Conclusions

The Spanish lambs fed with concentrate had lowest SFA proportion and higher PUFA proportion, therefore they had a better ratio P/S compared with the rest of the lambs types. The Uruguayan light lambs were similar to Spanish lambs in relation to PUFA proportion, and Uruguayan heavy, German and British lambs showed similar proportions of CLA, SFA and PUFA as well as P/S. Uruguayan heavy lambs had lower *n*-6/*n*-3 ratio in comparison with the German lambs, being the United Kingdom lambs placed between them.

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Tables and figures

Table 1. Fatty acid composition of *longissimus lumborum* muscle in percentage by weight of total fatty acids of lambs from typical production system from diverse countries.

	Spain	Germany	UK	Uruguay Light	Uruguay Heavy	CME	Sign.
Fat %	2.41 ^{c}	4.25 ^{b}	4.32 ^{b}	3.05 ^{c}	5.92 ^{a}	1.720	***
C10:0	0.24 ^{a}	0.23 ^{a}	0.16 ^{b}	0.22 ^{a}	0.22 ^{a}	0.004	***
C12:0	0.42 ^{a}	0.30 ^{b}	0.16 ^{c}	0.27 ^{b}	0.12 ^{c}	0.014	***
C14:0	3.77 ^{a}	3.62 ^{a}	2.36 ^{b}	3.60 ^{a}	2.55 ^{b}	0.759	***
C14:1	0.15 ^{a}	0.12 ^{b}	0.06 ^{c}	0.11 ^{b}	0.07 ^{c}	0.002	***
C15:0	0.47 ^{a}	0.49 ^{a}	0.43 ^{a}	0.41 ^{a}	0.32 ^{b}	0.009	***
C16:0	22.58 ^{b}	23.65 ^{ab}	23.43 ^{b}	24.73 ^{a}	24.66 ^{a}	2.302	***
C16:1	1.81 ^{a}	1.39 ^{b}	1.32 ^{b}	1.42 ^{b}	1.44 ^{b}	0.080	***
C17:0	1.31 ^{a}	1.04 ^{b}	1.10 ^{b}	1.07 ^{b}	1.02 ^{b}	0.035	***
C17:1	0.98 ^{a}	0.64 ^{c}	0.75 ^{b}	0.56 ^{c}	0.59 ^{c}	0.019	***
C18:0	12.56 ^{d}	18.79 ^{ab}	19.78 ^{a}	16.62 ^{c}	17.49 ^{bc}	4.327	***
C18:1	39.63 ^{a}	39.05 ^{a}	40.51 ^{a}	35.81 ^{b}	40.56 ^{a}	6.640	***
C18:2	9.48 ^{a}	5.45 ^{b}	3.92 ^{c}	6.01 ^{b}	4.18 ^{c}	1.990	***
C18:3	0.56 ^{c}	1.48 ^{b}	1.62 ^{b}	3.37 ^{a}	3.19 ^{a}	0.352	***
CLA	0.40 ^{c}	0.97 ^{ab}	1.05 ^{a}	0.79 ^{b}	0.94 ^{ab}	0.096	***
C20:0	0.09 ^{ab}	0.10 ^{a}	0.09 ^{ab}	0.11 ^{a}	0.07 ^{b}	0.001	***
C20:3	0.28 ^{a}	0.14 ^{cd}	0.17 ^{c}	0.22 ^{b}	0.10 ^{d}	0.005	***
C20:4	3.99 ^{a}	1.22 ^{c}	1.13 ^{c}	1.94 ^{b}	0.86 ^{c}	0.593	***
C20:5	0.34 ^{c}	0.51 ^{c}	0.94 ^{b}	1.29 ^{a}	0.86 ^{b}	0.122	***
C22:5	0.68 ^{b}	0.58 ^{b}	0.81 ^{b}	1.14 ^{a}	0.60 ^{b}	0.076	***
C22:6	0.24 ^{ab}	0.21 ^{b}	0.22 ^{b}	0.31 ^{a}	0.17 ^{b}	0.010	***

^{a,b,c}Least square means in the same row with different superscript letters are different ($P<0.05$);

Table 2. Fatty acid ratios of *longissimus lumborum* muscle from typical production system from diverse countries.

	Spain	Germany	UK	Uruguay Light	Uruguay Heavy	CME	Sign.
SFA	41.44 ^{b}	48.23 ^{a}	47.51 ^{a}	47.04 ^{a}	46.44 ^{a}	5.540	***
MUFA	42.58 ^{a}	41.21 ^{a}	42.64 ^{a}	37.90 ^{b}	42.66 ^{a}	7.170	***
PUFA	15.58 ^{a}	9.60 ^{b}	8.80 ^{b}	14.27 ^{a}	9.96 ^{b}	8.015	***
P/S	0.38 ^{a}	0.20 ^{c}	0.19 ^{c}	0.31 ^{b}	0.21 ^{c}	0.006	***
***n*-6/*n*-3**	8.42 ^{a}	2.47 ^{b}	1.54 ^{bc}	1.36 ^{bc}	1.07 ^{c}	2.284	***
ATT	0.17 ^{e}	0.55 ^{d}	1.05 ^{b}	0.80 ^{c}	1.19 ^{a}	0.037	***

^{a,b,c}Least square means in the same row with different superscript letters are different ($P<0.05$); SFA: Saturated fatty acids; MUFA: Monounsaturated fatty acids; PUFA: Polyunsaturated fatty acids; P/S: PUFA/SFA; *n*-6/*n*-3: (C18:2+C20:3+C20:4)/(C18:3+C20:5+C22:5+C22:6); ATT: (C20:3+C20:5)/C20:4.

Figure 1. Projection of the fatty acid data in the plane defined by the two first principal components

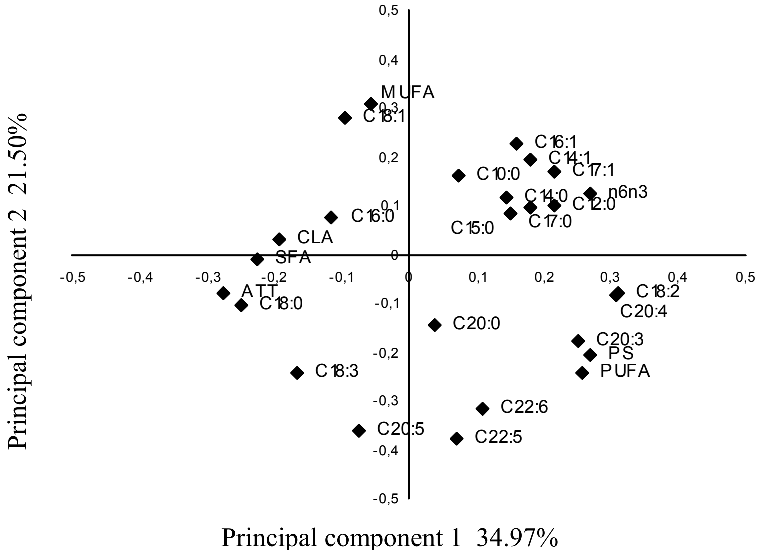

Figure 2. Projection of the fatty acid data of the five groups studied in the plane defined by two principal components. ▵Uruguayan light lambs. ×Uruguayan heavy lambs. □Spanish lambs.
○ British lambs. ● German lambs.