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Influence of commercial cut on proximate composition and fatty acid profile of Rasa Aragonesa light lamb

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ABSTRACT

The aim of this work was to assess the proximate and fatty acid (FA) composition of the edible portion, including fat and muscle, of different commercial cuts in lamb. Ten entire males belonging to the Protected Geographical Indication 'Ternasco de Aragón', weaned at about 50 days old and intensively fed with concentrate and cereal straw *ad libitum* until reaching 80 days old, were used. Seven commercial cuts were assessed: leg, shoulder, neck, shoulder-ribs, loin + rack, breast and flank. The leanest cut, considering the edible composition, was the leg, with a fat content of 11.5%, although not statistically different from the neck, shoulder and shoulder-ribs. The fattest cut was the breast (42%), although it contributed little to the total fat content of the animal representing only 4.5% of the whole carcass weight. Few differences were found in the percentages of FA and were mainly associated with the minor FA, although shoulder-ribs and loin + rack had the highest percentage of stearic acid. However large differences were found in the amount of FA among commercial cuts.

1. Introduction

Food composition data are essential for the assessment of nutrient intake and the development and subsequent application of food policies (Defagó et al., 2015) brought about due to the increasing problem of human obesity in developed countries. An excess of energy intake along with a sedentary lifestyle has been considered its main contributors (Hill and Melanson, 1999), although more factors are implicated including the amount and composition of the fat in the diet (Moreno and Rodríguez, 2007). The consumption of red meats, such as lamb, is associated with diets with a high fat content especially those containing saturated fat (Ursin et al., 1993). Certain saturated fatty acids have been linked to cardiovascular disease (Salter, 2013), therefore recommendations exist to avoid the intake of meat from ruminants. Other studies however have shown that ruminant meat, more specifically lamb, is rich in some micronutrients (Campo et al., 2013) necessary for a healthy status, and frequent consumption is not negatively related to changes in body composition or cardiovascular risk (Mesana et al., 2013). Note that the annual consumption of red meat is currently declining, reaching in Spain 1.24 kg/person of lamb meat and 5.69 kg/person of beef in 2015, from the 37.1 kg/person of fresh meat and 50.1 kg/person including processed meat (MAGRAMA, 2016).

Nevertheless, sheep production is important in Mediterranean countries (Sañudo et al., 1998), with higher levels of consumption in certain regions [3.4 kg/person/year in Aragón (MAGRAMA, 2016)]. The typical production system in this area is characterised by either obtaining ewe's milk and a very young suckling lamb of approximately 30 days old, or several types of lambs weaned between 40 and 50 days old, reared on cereal-based concentrates in communal fattening units and slaughtered at a light weight (less than 13 kg of carcass weight) (Campo et al., 2016). This differs from other world areas, with heavier breeds and animals that can be reared under grazing conditions, affecting the characteristics of their meat (Díaz et al., 2005; Sañudo et al., 2000). Although using food composition data from other countries may be appropriate, local ingredients or preparation methods may require modification of the data (Pennington, 2008), which can also evolve over the time (Sainsbury et al., 2011), due to changes in the production systems, feeding or management of the animals.

There is an ongoing process in updating certain databases that are used worldwide as a reference (Acheson et al., 2015). In the case of lamb, much effort has been done in assessing the composition of specific muscles, especially *longissimus dorsi* muscle due to its larger size in comparison with other muscles. However, the consumption includes also some subcutaneous and intermuscular

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adipose tissues that, most of the times, are not included in the analysis but contribute to the total fat intake in the diet. Since 80% of the purchase of lamb in Spain is performed after splitting the carcass in different joints (MAGRAMA, 2015a), the aim of this work was to assess the lipid composition of the edible portion, including lean and visible fat, of different commercial cuts of light lamb reared in Spain.

2. Material and methods

2.1. Materials

All reagents were of analytical grade (Panreac, Barcelona, Spain). For fatty acid analysis, methyl nonadecanoate was used as internal standard (Sigma-Aldrich, Buchs, Switzerland).

2.2. Sampling

Ten entire males of Rasa Aragonesa breed, originating from different farms, reared in the same fattening unit, belonging to the Protected Geographical Indication (PGI) 'Ternasco de Aragón' and with a cold carcass weight of 9.90 ± 0.28 kg were selected at an EU-licensed abattoir 24 h after slaughtering. Approximately 90% of these animals in this PGI are slaughtered in this abattoir, and have been previously reported to have around 47% of dressing percentage at this carcass weight (Martínez-Cerezo et al., 2005). These animals had been with their mothers without access to grass due to typical dry environmental characteristics, weaned at 50 days old and reared at a communal fattening unit on concentrates (a mixture of barley, maize, soya and sunflower seeds, with 13.3% crude protein and 4.2% ether extract) plus cereal straw *ad libitum* until slaughter at around 80 days old. This husbandry system and diet is largely used for this type of animals that comprises 52.3% of a total 9.2 million lambs slaughtered in Spain in 2014 (MAGRAMA, 2015b). Following a standardized procedure (Colomer-Rocher et al., 1988), the left side of the carcass without the tail, kidney and perirenal fat was divided into seven commercial cuts: leg, shoulder, neck, shoulder-ribs, loin + rack, breast and flank (Fig. 1). The shoulder ribs included the first five ribs, which are located under the shoulder lacking subcutaneous fat. The shoulder was extracted after cutting the subcutaneous layer following imaginary lines in the neck at the 4th vertebra, between the 4th and 5th thoracic vertebrae and perpendicular up to the elbow. The leg was separated after the 6th lumbar vertebra level. The loin + rack cut was obtained between the 6th thoracic and 6th lumbar vertebrae. The width of the loin + rack reached an imaginary line between the manubrium, across the abdominal muscles up to the knee. The breast and flank were divided by the 5th sternebra. Each cut from each animal was weighed (expressed as percentage of the half carcass weight) and deboned. Then for each cut and animal the lean was weighed again together with any visible fat tissues, which were considered as the edible part of the cut. These tissues were ground in a cutter SAMMIC-SK3 (Sammic S. L., Azcoitia, Spain) at 1700 rpm for 30 s. Afterwards, approximately 100 g of ground sample for each cut and animal were taken, vacuum packaged, immediately frozen and kept at −18 °C until analysed.

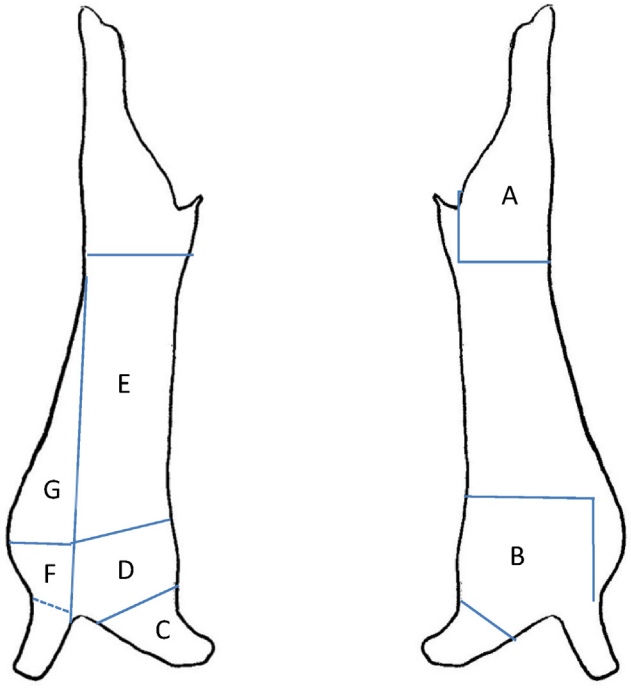

Fig. 1. Standardised commercial cuts for Spanish light lamb. A: Leg; B: Shoulder; C: Neck; D: Shoulder ribs; E: Loin + rack; F: Breast; G: Flank.

2.3. Proximate analyses

After thawing by placing the samples at room temperature (17–19 °C) maintaining vacuum conditions, minced samples were homogenized again with a mixer (Moulinex 320, Groupe SEB, Ecully, France) prior to determination of dry matter (ISO, 1997), total fat (ISO, 1973), protein (ISO, 1978) with a conversion factor of 6.25 and ashs (ISO, 1998). All analyses per cut were performed in duplicate.

2.4. Fatty acid analyses

Total lipids were extracted in chloroform:methanol using a modification of Bligh and Dyer (1959) with 10 g of sample [complete details are reported elsewhere (Carrilho et al., 2009)]. After drying under a stream of N2, methyl esters were obtained with KOH (2 N in methanol) by adding 3 mL of this solution to 0.03 g of extracted fat previously dissolved in 2 mL of *n*-hexane. Closed tubes were shaken vigorously for 20 s at room temperature. Once the solution became clear, 1 μL of *n*-hexane layer was analysed by gas chromatography using an HP 6890 gas chromatograph (Agilent Technologies, Madrid, Spain) equipped with a flame ionization detector and an automatic injection system (HP 7683), and fitted with an SP 2560 column (100 m × 0.25 mm × 0.20 μm) with N2 as a carrier gas at a constant flow of 0.8 mL/min. Split injection with 1:32 split ratio was applied. Oven temperature programming was as follows: column temperature was set at 140 °C, then raised at a rate of 3 °C/min up to 158 °C, and 1 °C/min to 165 °C, kept for 10 min, raised at 5 °C/min to 220 °C and kept constant for 50 min. Inlet temperature was set at 230 °C and detector at 240 °C. C19:0 methyl ester was used as an internal standard. Samples were assessed in duplicate.

Fatty acids were expressed as percentage of total fatty acids and as mg/100 g of sample. In addition, several nutritional indices were calculated (Ulbricht and Southgate, 1991; Díaz et al., 2005):

$$ATT = (C20{:}3\ n\text{-}6 + C20{:}5\ n\text{-}3)/C20{:}4\ n\text{-}6;$$

$$AI = (C12{:}0 + 4{*}C14{:}0 + C16{:}0)/(n\text{-}3\ PUFA + n\text{-}6\ PUFA + MUFA);$$

$$TI = (C14{:}0 + C16{:}0 + C18{:}0)/(0.5{*}MUFA + 0.5{*}n\text{-}6\ PUFA + 3{*}n\text{-}3\ PUFA + n\text{-}3\ PUFA/n\text{-}6\ PUFA);$$

Where ATT = antithrombotic potential; AI = atherogenic index; TI = thrombogenic index; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

2.5. Statistical analysis

A General Lineal Model was applied with commercial cut as a fix effect and animal as a block using SPSS 22.0. When significant, a Duncan test ($p \leq 0.05$) was used to assess differences in the mean values.

3. Results and discussion

The leg was the biggest commercial cut, followed by the loin + rack and the shoulder ($p < 0.001$; Table 1). These three cuts accounted for 72.6% of the half carcass weight. These percentages do not coincide with other findings (Badiani et al., 1998; Cifuni et al., 2000; Sheridan et al., 2003), due to the different breeds, slaughter ages and, especially, the different commercial cuts used in different countries. Three months old Suffolk rams weaned just before slaughtering showed the leg as 31.8% weight of the carcass (Badiani et al., 1998). This represents more than 3 points higher than Rasa Aragonesa lambs slaughtered at a similar age, due to the higher meat conformation of Suffolk breed. Rasa Aragonesa lambs showed 53.0% of leg and loin + rack that together with shoulder-ribs reached 61.5%. Apulian lambs had 56.0% at a similar carcass weight for rack + loin + leg but younger animals, and 56.6% at a similar age but in heavier carcasses (Cifuni et al., 2000), whereas the percentage of thick-rib + rib + buttock in South African Mutton Merino would vary between 56.9 to 58.6% in older and much heavier animals (20–24 kg carcass weight, Sheridan et al., 2003). This variation related to differences in commercial cuts supports the analysis of different local products, making difficult the comparison of meat composition between countries. The total percentage of edible tissues in the carcass was 75.2% considering the composition of each cut and their relative importance in the whole carcass. On the major cuts, values of edible tissues varied between 74.6% in the loin + rack and 78.6% in the shoulder. However, the cut with the highest yield of edible tissue (85.8%) was the flank. Values for the same cut in similar breeds are comparable, since the percentage of bone was 22.2% in the leg, identical to that found by Cifuni et al. (2000) in an Italian breed slaughtered at 90 days old, very similar to our animals. The percentage of bone in younger animals is higher, implying a later development of other tissues, especially adipose tissue (Camacho et al., 2015). Therefore, the percentage of edible tissues increases as the animal age increases.

The cut with the highest content of chemically-analysed total fat was the breast, with 42.1% ($p < 0.001$). However, this cut only represents 4.47% of the carcass, although it is one of the points where body condition score can be assessed in the live animal. Therefore, its contribution to the total fat intake is low. The leanest cut was the leg, although without significant differences from the shoulder, neck or shoulder-ribs (Table 2). These differences can be respectively attributed to the differential development of tissues in young animals throughout the body. In this breed, the amount of fat in the leg analysed by chemical methods was lower than that found by dissection by Cifuni et al. (2000) in Apulian lambs (11.5% *vs.* 15.6%). Although with a similar age, the heavier slaughter weight would imply a higher fatness, together with the higher precociousness of Apulian lamb that would deposit fat at a higher rate at 90 days old than Rasa Aragonesa lambs. However, this percentage was higher than that previously found in similar animals (11.5% *vs.* 9.6%), probably due to the different presentation of the leg, since the shank and part of the sacral vertebrae had not been previously included in the analysis (Campo et al., 2013). There is fat deposition at this level, very relevant in fat-tail breeds (Sañudo et al., 1997), although it is not the case in Spanish local breeds. The protein content was almost inversely related to the fat content because the cut with the lowest percentage of protein was the breast (10.5%) that showed the highest fatness ($p < 0.001$). The highest percentage of protein appeared to be in the front part of the body and in the limbs (shoulder, shoulder-ribs, neck and leg) without statistical differences with the flank, with values around 16%. No significant differences were found between commercial cuts in the percentage of ashes, as happens in most studies independently of the production factors analysed (Sainsbury et al., 2011; Sheridan et al., 2003) unless cooking is involved (Campo et al., 2013; Van Heerden et al., 2007).

Because most works in the literature about lipid composition are shown in specific tissues, either muscle or adipose tissues, data are not comparable especially if we consider data between countries. The same breed and sex analysed in the current study would show only 2.4% of intramuscular fat when the muscle *longissimus dorsi* is considered (Díaz et al., 2005). We have found 19.0% of total fat in the loin + rack, where the muscle *longissimus dorsi* comprises most of the ribeye, which indicates a large amount of intermuscular and subcutaneous fats in the joint that are not analysed if the muscle is considered on its own, but that can also be consumed. Data about the total amount of fat can also be affected by the husbandry system, increasing the total amount of fat with the age of the animal (Camacho et al., 2015; Díaz et al., 2005; Martínez-Cerezo et al., 2005).

Table 3 shows the fatty acid composition of the different cuts, considering together the lean (intramuscular fat) and the visible fat tissues (subcutaneous and intermuscular fats). Some fatty acids have shown significant percentage differences among cuts: C14:1, ($p < 0.05$); C18:1 *c*11, total conjugated linoleic acid (CLA) and C20:5 ($p < 0.01$); C17:0; C18:0, C20:0; C22:0, C16:1, C20:3 *n*–6, C20:4 *n*–6 and C22:6 *n*–3 ($p < 0.001$).

Among the major fatty acids, the loin + rack and the shoulder ribs showed the highest percentage of stearic acid (around 16%). The breast, that showed the highest total fat, had the highest percentage of total CLA and C16:1*n*–9 (2.64%), although not significantly different from the neck in the latter. However, among the polyunsaturated fatty acids, the leg had the highest percentage of C20:3*n*–6 (0.08%); arachidonic acid (0.88%), DHA (0.08%) and EPA (0.04%) (not significantly different from the neck in the last case). Other authors have analysed the composition of different fat tissues, finding that intramuscular fat is less saturated than either kidney knob fat (Horcada et al., 2014), intermuscular or subcutaneous depots (Osorio et al., 2007). The percentage of *n*–3 and *n*–6 fatty acids found are typical of those lambs intensively reared on concentrates. These data would greatly differ if animals

Table 1
Percentage of commercial cuts (in relation to the half carcass), muscle + visible fat and bone of light lambs ($n = 10$).

	Leg	Shoulder	Neck	Shoulder-ribs	Loin + Rack	Breast	Flank	RMSE	
% over carcass	28.4a	19.6c	7.21d	8.45d	24.6b	4.47e	7.22d	1.54	<0.001
% muscle + visible fat	77.7bc	78.6b	66.3d	66.9d	74.6c	62.2e	85.8a	3.7	<0.001
% bone	22.2cd	21.3d	33.7b	33.0b	25.4c	37.8a	14.2e	3.7	<0.001

RMSE: root mean square error. a, b, c, d, e: mean values in the same column with different letters differ significantly ($p \leq 0.05$).

Table 2
Proximate composition (100 g of edible portion as a wet weight basis) of the commercial cuts of light lamb ($n = 10$).

	Leg	Shoulder	Neck	Shoulder-ribs	Loin + Rack	Breast	Flank	RMSE	
Moisture	71.7a	70.3ab	69.5ab	68.2ab	66.2b	46.4d	61.8c	3.0	<0.001
Fat	11.5c	12.7c	13.1c	14.6c	19.0b	42.1a	20.8b	2.9	<0.001
Protein	15.8ab	16.1a	16.3a	16.1a	13.9b	10.5c	16.2a	2.1	<0.001
Ash	0.94	0.95	0.99	1.06	0.90	0.90	1.19	0.16	0.08

DM: Dry matter. RMSE: root mean square error. a, b, c, d: mean values in the same row with different letters differ significantly ($p \leq 0.05$).

Table 3
Fatty acid composition (% of total fatty acids) of the edible portion of commercial cuts in light lambs ($n = 10$).

	Leg	Shoulder	Neck	Shoulder-ribs	Loin + Rack	Breast	Flank	RMSE	
SFA									
C10:0	0.26	0.25	0.24	0.24	0.24	0.26	0.28	0.06	0.72
C11:0	0.018	0.019	0.016	0.017	0.018	0.021	0.022	<0.001	0.29
C12:0	0.60	0.57	0.58	0.53	0.48	0.64	0.64	0.15	0.18
C13:0	0.056	0.054	0.052	0.046	0.047	0.060	0.057	<0.001	0.53
C14:0	5.54	5.50	5.56	5.21	5.04	6.17	5.92	1.23	0.45
C15:0	0.77	0.75	0.73	0.73	0.81	0.86	0.88	0.14	0.11
C16:0	24.5	24.7	24.5	23.9	24.0	24.7	25.5	1.44	0.23
C17:0	2.24bc	2.37b	2.30bc	2.32bc	2.58a	2.17c	2.35b	0.16	<0.001
C18:0	13.5b	14.1b	14.3b	16.2a	15.8a	13.9 b	14.0b	0.9	<0.001
C20:0	0.13c	0.14 c	0.14bc	0.17a	0.16ab	0.15bc	0.14bc	0.02	0.001
C22:0	0.14a	0.12bc	0.12bc	0.12b	0.11cd	0.09e	0.10de	0.01	<0.001
MUFA									
C14:1 *c*9	0.20ab	0.25a	0.20 ab	0.16b	0.16b	0.26a	0.20ab	0.07	0.01
C16:1 *c*9	2.05bc	2.14bc	2.29ab	2.03bc	1.77c	2.64a	1.95bc	0.39	<0.001
C17:1 *c*9	1.18	1.10	1.11	10.2	1.14	1.14	1.13	0.15	0.39
C18:1 *c*9	34.8	35.0	35.3	35.0	34.5	35.3	34.4	1.3	0.63
C18:1 *c*11	1.29ab	1.26abc	1.21cd	1.21cd	1.31a	1.19d	1.23bcd	0.07	0.002
C20:1 *c*9	0.15	0.15	0.16	0.16	0.16	0.15	0.15	0.02	0.93
C22:1 *c*9	0.007	0.008	0.008	0.011	0.009	0.089	0.012	<0.001	0.48
PUFA									
*t*C18:2*n*–6	0.25	0.26	0.27	0.27	0.20	0.28	0.26	0.06	0.13
C18:2*n*–6	5.41	5.01	4.85	4.92	5.19	4.41	4.75	1.44	0.81
Total CLA	0.54b	0.49b	0.53b	0.52b	0.49b	0.61a	0.53b	0.07	0.008
C18:3*n*–6	0.056	0.065	0.044	0.047	0.046	0.039	0.042	0.032	0.15
C18:3*n*–3	0.51	0.50	0.49	0.50	0.49	0.49	0.48	0.06	0.92
C20:2*n*–6	0.054	0.049	0.050	0.050	0.050	0.043	0.047	<0.001	0.47
C20:2*n*–3	0.019	0.029	0.014	0.015	0.014	0.008	0.013	<0.001	0.17
C20:3*n*–6	0.084a	0.068b	0.056bcd	0.064bc	0.053cd	0.044d	0.048d	<0.001	<0.001
C20:3*n*–3	0.014	0.016	0.013	0.014	0.013	0.012	0.011	<0.001	0.07
C20:4*n*–6	0.88a	0.58b	0.52b	0.54b	0.47bc	0.23d	0.36c	0.12	<0.001
C20:5*n*–3	0.038a	0.011c	0.029ab	0.012c	0.010c	0.014bc	0.013bc	<0.001	0.004
C22:6*n*–3	0.081a	0.054b	0.046bc	0.040c	0.041c	0.026d	0.034c	<0.001	<0.001
% SFA	47.8	48.5	48.6	49.5	49.3	49.1	49.9	3.0	0.74
% MUFA	39.7	39.9	40.3	39. 6	39.0	40.7	39.1	1.5	0.13
% PUFA	7.95	7.14	6.92	7.00	7.07	6.21	6.59	1.58	0.35
% *n*–6 PUFA	6.75	6.04	5.80	5.90	6.01	5.05	5.52	1.53	0.34
% *n*–3 PUFA	0.66 a	0.61 ab	0.59 b	0.58 b	0.56 b	0.55 b	0.55 b	0.07	0.006
n–6/*n*–3	10.6	10.3	10.2	10.5	10. 8	9.49	10.3	1.35	0.49
PUFA/SFA	0.17	0.15	0.15	0.14	0.15	0.13	0.13	0.04	0.54

RMSE: rootmean square error. a, b, c, d: mean values in the same row with different letters differ significantly ($P \leq 0.05$). Total CLA: sum of conjugated linoleic acid isomers. SFA: Saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids.

had been grazing (Díaz et al., 2005; Enser et al., 1998; Wood et al., 2004) since high amounts of *n*–3 fatty acids in the grass increase the deposition of α-linolenic acid and other *n*–3 fatty acids in the tissues. The same applies to the CLA composition, which is low in comparison with older animals that have been grass fed, either by direct grazing or hay supplementation (Díaz et al., 2005).

Even though there exist differences in individual fatty acids, no significant differences were found in the groups of fatty acids ($p > 0.05$) except for *n*–3 PUFA where the leg incorporated a higher percentage of these PUFA in comparison with the rest of the cuts apart from the shoulder.

Although differences among cuts were not significant in all data when assessing the fatty acid composition in percentage, the differences in the content were highly significant among the different cuts in all fatty acids except for C20:2 *n*–3 (Table 4). This has been directly related to the differences in fat content between the commercial cuts (Table 2). Therefore, the breast as the fattest commercial cut has shown the highest amount of each fatty acid when represented per 100 g of edible tissue. Nevertheless, this cut only represents 4.47% of the total carcass, and in real weight it would represent 139 g of edible tissue in the half carcass of the studied animals. On the other hand the leg, which is the biggest cut of the carcass and one of the leanest, showed the smallest amount of each fatty acid when calculated per 100 g of edible portion. This cut would contain 1105 g of edible tissue and would allow the consumption of lamb for 5 consumers in one meal considering the

Table 4
Fatty acid composition (mg of fatty acids/100 g sample) of the edible portion of commercial cuts in light lambs ($n = 10$).

	Leg	Shoulder	Neck	Shoulder-ribs	Loin + Rack	Breast	Flank	RMSE	
Total fatty acids	7335 e	9961d	12244cd	11146d	14200c	38719a	18515b	2525	<0.001
SFA									
C10:0	17.4d	22.6cd	28.1cd	25.4 cd	32.9c	88.4a	46.9b	12.6	<0.001
C11:0	1.26d	1.73 cd	1.79 cd	1.71 cd	2.41c	7.10a	3.55b	1.02	<0.001
C12:0	40.0c	52.5c	65.2c	55.9c	65.0c	220.4a	104.6b	32.2	<0.001
C13:0	3.62d	4.85 cd	5.79cd	4.79cd	6.36c	20.7a	9.45b	2.39	<0.001
C14:0	368d	506 cd	637c	554cd	667c	2129a	968b	268	<0.001
C15:0	48.2d	68.1d	74.6d	70.8d	102.c	294.1a	142.6b	28.2	<0.001
C16:0	1599e	2195d	2696cd	2410d	3045c	8507a	4167b	622	<0.001
C17:0	140.3d	204.8 cd	230.8cd	205.5cd	307.9bc	739.8a	375.1b	115.0	<0.001
C18:0	841e	1230de	1503cd	1565cd	1918bc	4776a	2240b	520	<0.001
C20:0	8.27e	12.4de	15.0 cd	16.2cd	19.3bc	51.2a	23.0b	5.61	<0.001
	27e								
C22:0	8.77d	10.1 cd	11.9c	11.2cd	12.8c	30.9a	15.7b	3.08	<0.001
MUFA									
C14:1 *c*9	13.8c	21.8bc	24.7bc	17.4c	20.7bc	90.2a	33.2b	13.7	<0.001
C16:1 *c*9	139.6e	191.8de	266.6 cd	205.3cde	225.0de	911.5a	321.0b	104.0	<0.001
C17:1 *c*9	77.1d	96.3cd	114.7cd	92.5cd	137.0bc	389.2a	181.3b	49.8	<0.001
C18:1 *c*9	2277e	3097d	3859cd	3485cd	4266c	12163a	5620b	879	<0.001
C18:1 *c*11	82.9e	111.3de	127.1cd	114.1de	159.1c	405.8a	199.3b	39.7	<0.001
C20:1 *c*9	10.0e	13.4de	16.7 cd	15.3d	19.6c	51.9a	24.4b	4.53	<0.001
C22:1 *c*9	0.47c	0.64bc	0.73bc	1.00abc	1.07abc	2.03a	1.61ab	1.07	0.02
PUFA									
tC18:2*n*–6	17.3c	23.5c	32.2bc	28.9bc	23.5c	97.0a	43.4b	18.3	<0.001
C18:2*n*–6	337d	396 cd	506abc	456 cd	612bc	1481a	765b	240	<0.001
Total CLA	36.5d	45.6 cd	60.7c	54.3 cd	63.3c	210.7a	88.6b	20.0	<0.001
C18:3*n*–6	3.50c	6.30bc	4.65bc	4.34bc	5.57bc	13.1a	6.76b	3.16	<0.001
C18:3*n*–3	33.0e	41.2de	53.6 cd	48.6 cd	59.2c	165.3a	77.9b	15.1	<0.001
C20:2*n*–6	3.44e	4.00de	5.26 cd	4.67cde	5.95c	14.4a	7.63b	1.79	<0.001
C20:2*n*–3	1.31	1.79	1.57	1.52	1.76	2.85	2.21	1.16	0.08
C20:3*n*–6	5.10c	5.66c	5.91c	5.93c	6.40bc	14.9a	7.88b	1.85	<0.001
C20:3*n*–3	0.88c	1.37bc	1.35bc	1.32bc	1.50b	3.92a	1.80b	0.53	<0.001
C20:4*n*–6	52.4bc	46.6c	51.4bc	46.8c	53.4bc	77.2a	57.7b	10.5	<0.001
C20:5*n*–3	2.95bc	1.04c	3.38b	1.17bc	1.33bc	5.47a	2.22bc	2.29	0.001
C22:6*n*–3	5.95bc	5.29bc	5.97bc	4.59c	5.83bc	10.1a	6.92b	1.66	0.001
SFA	3079e	4311d	5272cd	4925d	6183c	16872a	8100b	1292	<0.001
MUFA	3023e	4127d	5099cd	4542d	5807c	16254a	7577b	1084	<0.001
PUFA	499d	579e	732cd	658 cd	840bc	2098a	1069b	260	<0.001
n–6 PUFA	419d	483 cd	606cd	550 cd	707bc	1699a	889b	250	<0.001
n–3 PUFA	44.1e	50.7de	65.9cd	57.2cde	69.7c	187.6a	91.0b	16.5	<0.001
ATT	0.14a	0.14a	0.17a	0.15a	0.14a	0.27b	0.18a	0.04	<0.001
AI	0.90	0.91	0.91	0.88	0.86	0.96	0.98	0.19	0.83
TI	1.55	1.59	1.61	1.66	1.62	1.62	1.63	0.20	0.87

RMSE: rootmean square error. a, b, c, d, e: mean values in the same row with different letters differ significantly ($p \leq 0.05$). Total CLA: sum of conjugated linoleic acid isomers. SFA: Saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids ATT (Antithrombotic potential) = (C20:3 *n*–6 + C20:5 *n*–3)/C20:4 *n*–6. AI (Atherogenic index) = (C12:0 + 4*C14:0 + C16:0)/(*n*–3 PUFA + *n*–6 PUFA + MUFA). TI (Thrombogenic index) = (C14:0 + C16:0 + C18:0)/(0.5*MUFA + 0.5**n*–6 PUFA + 3**n*–3 PUFA + *n*–3 PUFA/*n*–6 PUFA).

cooking losses and the daily intake recommendations. According to their lower amounts of fatty acids, the leg, the shoulder and the shoulder-ribs would be the most recommended cuts to be consumed.

As the dietary factors linked to the incidence of coronary heart disease are very complex, certain fatty acid ratios have been proposed due to the different effect of some fatty acids in atherosclerosis and thrombosis regarding the risk of the potential aggregation of blood platelets (Ulbricht and Southgate, 1991) to assess the nutritional properties of food. From these indices only ATT [(C20:3*n*–6 + C20:5*n*–3)/C20:4*n*–6] was significantly higher in the breast than in the other cuts. The atherogenic index (AI) can be considered a suitable measure of the atherogenicity of foods (Ulbricht and Southgate, 1991). In general, ranges from 0.5 to 1 in meat fats have been reported (Turan et al., 2007), while values less than 0.5 have been described in vegetable oils. The thrombogenic index (TI) can be considered as an indicator of the thrombogenicity of foods. However, even with a higher percentage of *n*–3 PUFA in the leg, no significant differences were found in PUFA/SFA; *n*–6/*n*–3 ratios, AI or TI between the cuts, which indicates that in terms of nutritional ratios, the composition throughout the whole carcass is fairly homogeneous.

4. Conclusion

In light weight lambs, the flank is the cut with the highest percentage of edible tissue, although the leg is the largest joint of the total carcass. The breast has substantially higher fat content than the other cuts. However, in terms of percentage, few differences have been found in the fatty acid composition of the edible tissues between the different cuts, although the leg showed lower stearic acid and higher arachidonic acid, EPA and DHA percentages compared to the other cuts. According to the total fat intake in the diet, specifications about the joint should be included

in nutritional data, due to large differences in the amounts of fatty acids; however, in terms of fatty acid percentage, small differences can be found between the different joints of the same animal, which would allow the analysis of the edible portion of a cheap joint of the carcass to be representative of the rest of the joints.

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