PS7.04 Influence of cooking method on the fatty acid composition of edible lamb 325.00

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***Abstract*—Thirty lambs were used to assess the influence of cooking method on the fatty acid composition. With this aim, the left leg without shank, deboned and untrimmed of any adipose tissue was analyzed raw, and the right leg was analyzed in the same conditions after undertaking one of three cooking procedures: stew, grill or roast. Any cooking procedure increased the percentage and content of fatty acids in relation to the raw meat while comparing the same quantity of food. This increment was mainly due to the increase in dry matter caused by the water losses during cooking. Stewing showed the highest increase in fat, maybe due to the absorption of fat from the ingredients used in the recipe. This implied an extraordinary increment on the percentage of linoleic acid. *n*-3 fatty acids were less affected by cooking than *n*-6 fatty acids. Stewing would improve the fat quality according to cardiovascular indexes although the excess of fat should be taking into account. The composition of roast or grilled lamb was very similar, even when the length of cooking was very different.**

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***Index Terms*—fatty acids, roast, grill, stew, lamb.**

I. INTRODUCTION

OBESITY is one of the biggest health problems that concerns developed countries. The excessive intake of calories and sedentary life have been considered as the main cause of overweight [1], although there are more factors involved, among them, the fat intake and the habits of food consumption [2]. The consumption of red meat has traditionally been associated with diets with high content on saturated fats [3], therefore, it has been suggested its suppression from hipocaloric diets. However, the recommendations follow incomplete data, mainly from animals from different husbandry systems or references in raw samples, whilst red meat is mainly consumed cooked. Heat treatment has a significant impact on the composition and physicochemical characteristics of final food. Production factors, such as breed, age, feeding system or food composition, have been shown as important constituents in the fatty acid composition of lamb [4, 5] although the interaction between the raw ingredients and the cooking procedure has not been studied in depth.

The aim of this study was to assess the influence of three common cooking procedures on the fatty acid composition of a commercial cut in lamb, such as the leg, in similar conditions as the consumer would use at home.

II. MATERIALS AND METHODS

Thirty lambs, 6 males and 24 females, with 9.93 ± 0.60 kg of cold carcass weight, belonging to the label 'Ternasco de Aragon PGI', were selected 24 hours after slaughtering at an EU-licensed abattoir. Both legs were obtained following commercial procedures. The shank from each leg was discharged and the rest, untrimmed of surface adipose tissue, was individually vacuum packaged and kept at 4 ºC until reaching 4 days of ageing. In order to analyze the composition of the raw product, the left leg from each animal was deboned, cut into pieces and all muscles, together with connective tissue, intermuscular and subcutaneous fats were ground in a cutter SAMMIC-SK3 at 1700 rpm for 30 seconds. Then, a homogeneous sample was taken, vacuum packaged, immediately frozen and kept at -18 ºC until analyzed. The right legs were randomly assigned to one of three cooking procedures, with two males in each treatment: grill, stew and roast. Legs were deboned prior to cooking. Legs used for grilling were sliced into 1cm-thick steaks. Grilling was performed on an industrial single-plate grill at 200 ºC burnished with 10 ml of virgin olive oil for all the steaks, turning over after 30 seconds until reaching 75 ºC of internal temperature. Those legs stewed were cut into pieces, placed individually on a stainless-steel pan simmered with 10 ml of virgin olive oil, 250 ml of water and 30 g of ground almonds, covered with a ladle and kept

on a cooker at 180ºC for 1 hour and fifteen minutes approximately until reaching an internal temperature of 75 ºC. Those legs used on the roast were individually placed on a stainless-steel baking tray, covered with 10 ml of virgin olive oil and cooked in a gas oven at 200ºC for 1 hour and fifteen minutes approximately, turning once, until reaching 75ºC of internal temperature. All cooked samples were spread with a hitch of salt prior to cooking. Fifteen minutes after cooking and cooling, meat was slightly shaken to avoid excess of juice or any other ingredient, cut into pieces in the case of stewed and roast, and mixed and homogenized, as previously explained for the raw samples. Then, a mixed sample was vacuum packaged, frozen and kept at -18ºC until analysis was performed.

Fatty acids were extracted in chloroform:methanol [6]. Methyl esters were obtained with KOH in methanol and analyzed by gas chromatography in a HP 6890 equipped with a flame ionization flame and an automatic injection system (HP 7683), and fitted with a SP 2380 column (100m x 0.25 mm x 0.20 μm) with N as a carrier gas and C19:0 as an internal standard. Complete details can be checked elsewhere [7].

A General Lineal Model was applied with treatment as a fix effect using SPSS 14.0. When significant, a Duncan test was used to assess different mean values.

III. RESULTS AND DISCUSSION

The total fat content of the raw leg was higher than current values assigned to lambs raised in similar intensive conditions [8], even higher than older animals raised on pastures. The fact that most analysis in the literature are done on a lean muscle such as Longissimus dorsi (LD) influences this comparison. A level of 2.41 % of intramuscular fat in LD [8] has been found in light male lambs from the same breed, origin and husbandry conditions as the ones used in our study, although the fact of having more females than males may increase the amount of intramuscular fat since they are more precocious. However, the consumption of lamb is never done in just one muscle; there is always a mixture of muscles plus some intermuscular and subcutaneous tissues that increases the amount of fat that is finally consumed, even if the consumer partially trims the food in the plate. In our case, a 4-fold increase has occurred between the fat content of the LD and the leg, considering all tissues.

Any cooking procedure analyzed increased the percentage and content of fatty acids compared to the raw meat, when considering the same weight of raw and cooked meat. This increment is mainly due to the increase in dry matter (DM) due to the water losses during cooking (data not shown). DM significantly varied from 29.5 % in the raw meat to 41.6 % in both roast and stewed meat, with grilled meat in intermediate values. However, we have considered the cooked meat that would be effectively eaten by the consumer. This is the reason why we have not taken into account the water loss and considered 100g of either raw or cooked food. The higher values in the fat percentage of stew meat may have been influenced by the additional ingredients during cooking, especially the almonds, even if they were mostly taking apart before the analysis. Therefore, the consumption of roast lamb would imply the intake of 26 % more fat and for grilled lamb of 29 % more fat than the composition of the raw product. Stew lamb under these cooking conditions showed an increase of 41% of fat in relation to the raw product, when it only increased 29% its dry matter. This would imply, firstly, that in a moist-heat cooking procedure lamb cannot lose most of its components due to a lower temperature of the liquid surrounding the food, and that the increase was mainly due to the absorption of fat from the ingredients used in the recipe [9].

Only the percentages of C15:0, C15:1, C16:0, C16:1, C18:1 *n*-9, C18:2 *n*-6, C20:0, CLA and C22:0 out of the 29 fatty acids shown (Table 1) were significantly affected by the cooking method. Except for C20:0, with less levels in roast lamb, the rest of fatty acids were found in similar proportions in roast and grilled lamb. This fact, together with the similar fat percentage and amount of fatty acids/100 g sample would indicate that the use of a dry-heat cooking method at high temperature (grill or roast) would alter the fatty acid composition in a similar way when they reach the same internal temperature, independently of the length of the cooking procedure, since they differed from over a minute to over one hour. Similar results have been found with other dry-heat cooking methods [10]

The largest differences between treatments appeared for palmitic, oleic and linoleic acids. The percentage of palmitic acid largely decreased in stewed lamb versus grilled, roast or the raw meat ($p \leq 0.001$) with an 18% decrease in relation to the composition of the raw sample. Although not significant ($p \leq 0.1$), stearic acid also showed a decreased of 18% in comparison with the raw product. Long length heat treatment would favour the melting of saturated fatty acids. The main difference between stewing and roast, also considered a long length cooking method, was the presentation of the food, where the leg was cut in chunks for the stew, which would allow a longer temperature action to a larger surface losing more

compounds, whereas the entire leg was used in the roast minimising the exposed surface area to the heat.

However, oleic acid and, especially, linoleic acid, increased extraordinary in the stew in relation to the other treatments. The high content in oleic acid (71%) and linoleic acid (21%) of almonds may have contributed to such a large difference.

The behaviour of palmitic and stearic acids was reflected in the percentage of saturated fatty acids (SFA), where stewed lamb showed 8% less SFA than raw lamb. Although not significantly different from the raw product, grilled lamb, which was also cooked sliced and therefore, with a large surface contact with the heat, showed a decreased in SFA versus raw or roast meat. The percentage of unsaturated fatty acids followed the opposite tendency, especially polyunsaturated fatty acids (PUFA), in higher proportion in stewed than in raw, roast or grilled meat, mainly due to the composition of *n*-6 fatty acids, of which linoleic acid is the major fatty acid. The fact that *n*-3 PUFA are structural lipids that are less susceptible to alterations by cooking has been suggested as a hypothesis [11] for the less impact of cooking in this group of fatty acids than in others. As a consequence, stewed lamb showed a very high *n*-6/*n*-3 PUFA ratio, far away from the recommendations [12], although it had a more favourable PUFA/SFA ratio than the rest of treatments, close to the desirable 0.4. The ratio (I1) between the not hypercholesterolaemic major fatty acids (C18:0 + C18:1) and the major hypercholesterolaemic fatty acid (C16:0) [13] was significantly higher in the stew than in the rest of treatments. This better ratio was also found in the atherogenic (AI) and thrombogenic (TI) indexes [14], where stewed lamb showed a decreased of 31% and 41% for AI and TI respectively in relation to the raw product and the other cooking procedures analyzed.

IV. Conclusion

Cooking method highly influences the fatty acid content and composition of edible lamb, mainly by increasing the dry matter. No differences have been found between dry-heat cooking methods, even when the length of cooking is considerable different. A moist-heat cooking method such a stewing influences the fatty acid composition of the product in a larger scale, mainly due to the composition of the ingredients added to the recipe and their possibility to interact with the food, increasing especially the percentage of *n*-6 PUFA. Except for the ratio *n*-6/*n*-3, stewing would improve the fat quality of lamb according to cardiovascular indexes, although the increment in the level of fat should be taking into account.

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Table 1. Fat content (%) and fatty acid composition (% of total fatty acids and total mg/ 100 g sample) of the leg of light lambs fed on concentrates

	Raw	Roast	Grilled	Stewed	RMSE	
Fat	8.36 c	11.22 b	11.63 b	14.04 a	9.644	***
mg FA/100g	6471.7 c3	8356.28 b	8994.06 b	11242.531 a	7886.615	***
C10:0	0.23	0.26	0.25	0.17	0.130	ns
C12:0	0.50	0.62	0.49	0.34	0.375	ns
C14:0	4.85	5.19	4.86	3.56	2.328	ns
C14:1	0.18	0.19	0.19	0.15	0.070	ns
C15:0	0.74 a	0.77 a	0.71 a	0.58 b	0.277	*
C15:1	0.10 a	0.02 b	0.03 b	0.04 b	60.151	***
C16:0	24.03 a	24.39 a	23.87 a	20.36 b	6.224	***
C16:1 *n*-9	2.65 a	2.57 a	2.71 a	2.27 b	0.662	**
C17:0	2.04	2.06	1.81	1.75	0.558	ns
C17:1	1.08	1.10	0.97	0.96	0.259	ns
C18:0	13.40	12.91	12.58	11.38	3.229	ns
C18:1 *n*-9	34.89 b	34.48 b	36.27 ab	38.30 a	5.917	*
C18:1 *n*-11	1.35	1.39	1.31	1.45	0.195	ns
tC18:2 *n*-6	0.06	0.06	0.06	0.05	0.010	ns
C18:2 *n*-6	5.04 b	5.30 b	5.25 b	11.05 a	9.869	***
C20:0	0.11 b	0.11 b	0.14 a	0.15 a	0.071	***
C18:3 *n*-6	0.06	0.06	0.05	0.05	0.010	ns
C20:1 *n*-11	0.14	0.14	0.15	0.15	0.032	ns
C18:3 *n*-3	0.50 ab	0.47 ab	0.58 a	0.42 b	0.205	ns
Total CLA	0.66 a	0.62 ab	0.65 a	0.51 b	0.230	*
C20:2 *n*-6	0.05	0.05	0.05	0.04	0.010	ns
C22:0	0.14 b	0.14 b	0.14 b	0.20 a	0.100	**
C20:2 *n*-3	0.02	0.02	0.02	0.02	0.005	ns
C20:3 *n*-6	0.10	0.09	0.08	0.07	0.045	ns
C22:1 *n*-9	0.01	0.01	0.01	0.01	0.003	ns
C20:3 *n*-3	0.06	0.05	0.06	0.06	0.010	ns
C20:4 *n*-6	0.91	0.86	0.77	0.74	0.305	ns
C20:5 *n*-3	0.09	0.08	0.09	0.06	0.055	ns
C22:6 *n*-3	0.09	0.09	0.09	0.07	0.045	ns
% SFA	46.04 a	46.47 a	44.83 a	38.49 b	12.524	***
% MUFA	40.41 b	39.91 b	41.64 ab	43.32 a	5.164	*
% PUFA	7.63 b	7.76 b	7.76 b	13.14 a	9.102	***
% *n*-6	6.21	6.42	6.27	12.00	9.566	***
% *n*-3	0.76	0.72	0.83	0.62	0.281	ns
n-6/*n*-3	9.03 b	9.47 b	8.64 b	20.88 a	19.767	***
PUFA/SFA	0.17 b	0.17 b	0.17 b	0.35 a	0.298	***
ATT	0.22	0.21	0.23	0.19	0.063	ns
I1	2.09 b	2.02 b	2.11 b	2.53 a	0.753	**
AI	0.62 a	0.65 a	0.60 a	0.43 b	0.322	***
TI	7.94 a	7.86 a	7.33 a	4.71 b	5.238	***

RMSE: root mean square error
ns= no significant; * = p≤0.05; ** = p≤0.01; *** = p≤0.001
a, b, c: mean values in the same row with different letters differ significantly (p≤0.05);
Total CLA: sum of conjugated linoleic acid isomers
SFA: Saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids
ATT = (C20:3 *n*-3+C20:5 *n*-3)/C20:4 *n*-6;
I1 =(C18:0 + C18:1 *n*-9)/C16:0;
AI = (C12:0+C14:0+C16:0)/(*n*-3 PUFA + *n*-6 PUFA + MUFA);
TI = (C14:0+C16:0+C18:0)/(3*n*-3 PUFA + 0.5*n*-6 PUFA + *n*-3 PUFA/*n*-6 PUFA);