Effects of heating on the lipids and fatty acidsin Algerian pastured lamb meat

Benguendouz Abdenour[1*], Bouterfa Asma[2], Bouderoua Kaddour[3], Dahou Amine[4], Ait Saada Djamel[5], Benabdelmoumene Djilali[6], Amrane Abdeltif[7]

[1*,2,5]Laboratory of Food Technology and Nutrition, Department of Agronomy, Faculty of Natural Science and Life, Abdelhamid Ibn Badis University of Mostaganem, 27000. Algeria.
[3]Laboratory of Biotechnology Applied to Agriculture and Environmental Preservation, Higher School of Agronomy of Mostaganem, 27000. Algeria.
[4]Science and Techniques of Animal Production Laboratory, Abdelhamid Ibn Badis University, 27000, Mostaganem, Algeria
[6]Applied Animal Physiology Laboratory, Department of Agricultural Sciences, Faculty of Natural and Life Sciences, University Abdelhamid Ibn Badis of Mostaganem 27000, Algeria.
[7]Univ Rennes, École Nationale Supérieure de Chimie de Rennes, CNRS, ISCR (Institut des Sciences Chimiques de Rennes) –UMR 6226, F-35000 Rennes, France

***Corresponding Author:** Benguendouz Abdenour,
*Department of Agronomy, Faculty of Natural Science and Life, Abdelhamid Ibn Badis University of Mostaganem, 27000. Algeria. Email: abdenour.benguendouz@univ-mosta.dz

Received : 13/09/2023 ; **Accepted :**15/12/2023 ; **Published :**20/01/2024

Abstract
The aim of this work was to characterize lamb meat from grazing of Oum El Bouaghi and Souk Ahras area and to evaluate the impact of heat treatment on total lipids and fatty acids contained in legs and ribs lamb meat. Indeed, these experiments were conducted on REMBI lambs, aged of 6 to 8 months and a weight average of 32 kg. The legs (*Biceps femoris*) and ribs (*Longissimus dorsi*) meat were roasted at 180 °C; after heat treatment, the total lipids increased in legs and ribs, from (2.62% to 7.19% and from17.01 to 19.65%, respectively. Furthermore, the heat treatment caused a significant loss rate of PUFA in both muscles studied (16.78% vs. 8.50% for legs and 10.66% vs. 4, 81% for the chops). However, oven-roasted leads to a gain of both SFA (44.24% vs. 50.16% legs and 48.45% vs. 54.61% ribs) and MUFA (38.97% vs. 41.33 % for the legs and 40.56% vs. 40.88% for the ribs).

Keywords: Lamb, Meat, Fatty acids, Lipids, Heat.

Introduction

At a time when consumers are increasingly concerned about the composition and nutritional value of the content of their plates, professionals in the meat industry have taken a particular interest in the nutritional quality of meat products in recent years. Over the past two decades, Algeria has seen a rise in the consumption of red meat (Kardjadj and Dachung Luka., 2016). According to the same author, the estimated level of red meat consumption in Algeria is 11 kg/capita/year, which is significantly lower than that of developed countries. This can be attributed to the high cost of fresh red meat in Algeria.

Red meat is considered as a source of life and energy through its physiological and nutritional importance in terms of proteins, lipids, vitamins and mineral salts. These proteins are of high biological value (20 to 25%); they constitute the architectural support of the organism and are precursors of hormones, enzymes and antibodies. Lipids are essential for maintaining all cell membranes and are also precursors of hormones (prostaglandin) and fat-soluble vitamins (A, D, E, K). Mineral salts are easily absorbable (Fe++, Zn++) and are rich B vitamins group (B12). Thus, 100g of meat provides 40% of the daily intake for a good physiological balance (Hedwing, 2006). However, lamb meat, with its substantial energy intake of 205Kcal and its 20g of lipids per 100g of meat, has pieces that are more or less rich in lipids (Roasted leg, grilled rib with 8.9% and 17% respectively) (Geay et al., 2002).

In order to optimize the nutritional and dietary qualities of lamb meat, several research studies have been carried out, particularly those concerned with the fatty acid composition of adipose tissue and muscle tissue in the meat. The nature of the diet is the major factor in variations in meat quality.

Among the different types of feed, the effect of grazed or harvested grass is still poorly understood (Dozias et al., 1997). Our objective through this study was to characterize grass-fed meat, highlighting its content of lipids and fatty acids, beneficial to consumer health. A study by Santé-Lhoutellier et al. (2008) on grass-fed animals found that lipid oxidation levels in these animals are much lower than those in concentrate-fed animals. This is probably linked to the high levels of vitamin E provided by the grass.

Moreover, the choice of cooking as a parameter of this study is justified by the fact that it guarantees several qualities to consumers such as organoleptic, microbiological and nutritional qualities. But this heat treatment can thus have an effect on the oxidation of the lipids of the lamb meat during cooking; this phenomenon is more or less important according to the method of cooking applied. However, the richness of meat in antioxidants, particularly vitamin E, provided by grazing would limit these phenomena.
The purpose of this work was to characterize the meat of lamb from pasture in the steppe region of Oum el Bouaghi and Souk Ahras in terms of fatty acids and to study the effect of cooking type "Roti" on these highly sensitive biochemicals.

MATERIALS AND METHODS

Selection of animals: Ten lambs of the local Rembi breed were the focus of this study. All the lambs were male and aged between 6 and 8 months, with a homogeneous conformation and size. The lambs were selected based on their average live weight of 32.25 kg and were free of any internal or external affections. The lambs were followed in their natural environment of origin in the steppe regions of Oum el Bouaghi and Souk Ahras, known for their arid climate on their southern fringe and semi-arid on their northern part.

Diet: The lambs were fed a forage-based diet and had access to full-time grazing for a period of 100 days. The fodder consumed consisted primarily of vetch-oats, fodder oats, green barley, and peas-oats. The pasture comprised herbaceous plants of small to medium size that were perennial and resistant to the arid environment (xerophiles). The plants in these pastures included *Ampelodesma mauritanica* (DISS), *Artemesia herba alba L* (white mugwort), *Atriplex halimus*, and the most dominant plant was *Stipa tenacissima L*. (alfa).

Animal slaughter: Lambs that reached their target slaughter body weight after 100 days of grazing were fasted for approximately 24 h. The animals were slaughtered in places that comply with hygiene standards. After slaughter, the carcasses were resweated for 24 hours at 4°C then weighed before cutting them.

Carcass cutting: The carcasses were cut into two parts, one of which was used for the removal of tissues in the raw state and the other was intended for the removal of tissues undergoing cooking. Finally, other samples were taken for possible analyses.

Sample collection

Leg removal (Biceps femoris): Aliquots of lamb (100g-150g) from the 10 sacrificed lambs were taken, trimmed, then cut into small pieces in the raw and cooked state. The samples were ground using a high-speed rotary blade grinder, packaged in aluminum foil and stored at -18°C until analysis.

Removal of ribs (*Longissimus dorsi*): Rib samples (70g-100g) were taken between the 9th and the 12th ribs and then deboned. The recovered meat was ground in the raw state and in the cooked state using a high-speed rotating blade grinder, labelled, packaged in aluminum packaging and then stored at -18°C until analysis.

cooking meat: Cooking is the final stage of meat preparation before consumption. The cooking method, duration and intensity are adapted to the origin and quality of the meat. The cooking method used in our test was oven-roasted cooking. The meat without ingredients was roasted for 50 minutes at a temperature of around 180°C. The purpose of this type of cooking was to quickly coagulate the superficial proteins, to caramelize the starch in order to maintain the maximum of sapid and nutritious substances (Sucs) inside the meat.

Total lipids and gas chromatographic analysis

Total lipids: were extracted by a mixture of chloroform/methanol (2:1, by volume) according to Folch et al. (1957).
Fatty acid composition: The lipid extracts were saponified beforehand with NaOH sodium hydroxide, then methylated with methanol-BF3 according to the methanol-boron trifluoride method (Morisson and Smith., 1964). The fatty acid methyl esters were then separated, quantified and analyzed by gas phase chromatography (Perkin Elmer chromatograph) on a capillary column 30 cm long and 0.25mm diameter. The injector and temperature detector were set at 220°C and 280°C, respectively. Meanwhile, the oven temperature was programmed to increase from 45°C to 240°C, at a rate of 20°C to 35°C per minute. The 1µl aliquots were injected with bicyanopropil phenyl silicone as the stationary phase and hydrogen was used as the carrier gas. The fatty acid peaks were identified by comparison with the methyl retention time and the fatty acid quantification was made with reference to an internal standard (C17:0).

Statistical analysis: Statistical analysis was performed using ANOVA analysis (IBM SPSS software® version 20) followed by the Duncan test. Data were expressed as mean±SD and differences were considered significant for $p<0.05$.

Results and Discussions

The lipid content according to the nature of the muscle before and after cooking is illustrated in Table 1. The comparison of the lipid contents according to the muscle site shows a more marked superiority on the ribs compared to the leg. The difference can be estimated at about 8 times ($p<0.05$); this trend continued even after cooking since the difference is calculated at around 2.5 times. Indeed, after cooking, it appears that the lipid contents of the leg lamb increased by about

three times (2.62 Vs7.19g/100g). This increase linked to the heat treatment was only slightly felt for the lipids of the ribs (17.01 Vs 19.65g/100g). The lipid levels and the composition of their fatty acids (FA) from different types of muscle vary in ruminants depending on animal-related breeding factors (breed, sex, age) and its diet (basic ration , lipid supplements, etc.) (Bauchart and Thomas., 2010). These results agree with those of many authors (Prusa and Lonergan., 1987; Rabot, 1998) who have observed that cooking increases the lipid content of chicken meat. Also, our results corroborate those of Nikmaram et al. (2011) who found that roast-type cooking of camel meat leads to an increase in lipid levels from 5.4 to 6.16 g/100g, i.e. a gain of 12%. The increase in the total lipid content of both muscles after cooking is due to the dehydration of the meat. During heat treatment, the food undergoes thermomechanical deformations. It is the seat of coupled transfers of heat and water. These phenomena generate a pressure which causes the juice to migrate from the center of the muscle of the meat towards its surface, hence the formation of a crust which slows down the migration of water, profoundly modifies the evolution of the surface temperature and determines the final quality of the product (Kondjoyan and Peyron., 2006).
According to El Affifi et al. (2011), cooking increases the concentration of total lipids in grass-fed lamb meat. This content was 8.3 g/100g to increase to 12 g/100g after cooking. This consequence is linked to the loss of water during cooking. Compared to other research studies on the lipid content of meat products after cooking, a gain of 30% was observed for the pork chop, 22% for the sausage and 100% (highest content) for the meat of rabbit (Mourot et al., 2006). According to the same author, the high lipid content in rabbits after cooking can be explained by the nature of its meat, which contains little lipid, and therefore, has a higher water content.

Whatever the nature of the muscle, the fatty acid content of total lipids is modified by cooking. However, cooking led to a pronounced increase ($P < 0.05$) in the level of saturated fatty acids, while this same heat treatment led to a significant drop in the level of polyunsaturated fatty acids (PUFAs) in the two muscles studied (Biceps femoris and Longissimus sleeping). However, the level of monounsaturated fatty acids (MUFA) was not affected by cooking (Table 1).
The detailed fatty acid composition of the total lipids of the two muscles reveals a predominance of saturated fatty acids, representing more than 44% of the fatty acids identified. This proportion reached 50% after cooking.

Table 1: Total lipids ($g.100g^{-1}$) and fatty acids profile of lambs Biceps femoris and Longissimus dorsi provided from Souk Ahras and Oum El Bouagui (in % of identified FA).

	Before cooking		After cooking		Factors effects	
	Leg	Rib	Leg	Rib	Muscles	Cooking
Total lipids	2.62	17.01	7.19	19.65	P<0.05	P<0.05
C14 : 0	2.91	3.94	4.77	4.59	NS	P<0.05
C16 : 0	22.40	25.35	25.57	25.97	P<0.05	P<0.05
C16 : 1	0.47	0.48	0.45	0.50	NS	NS
C18 : 0	17.79	17.83	18.17	22.42	NS	P<0.05
C18 : 1 (n-9c)	34.37	36.19	37.12	36.67	NS	NS
C18 : 2 (n-6c)	9.14	5.71	5.07	3.44	P<0.05	P<0.05
C18 : 2 (n-6t) CLA	0.13	0.26	0.37	0.30	NS	P<0.05
C18 : 3 (n-3)	0.10	0.09	0.94	0.61	P<0.05	P<0.05
C20 : 0	0.13	0.13	0.06	0.10	NS	NS
C20 : 4 (n-6)	3.93	2.11	1.58	0.37	P<0.05	P<0.05
C22 : 5 (n-3)	1.26	0.76	0.52	0.08	P<0.05	P<0.05
C22 : 6 (n-3)	0.40	0.20	0.01	0.00	P<0.05	P<0.05
SFA	44.24	48.45	50.16	54.61	P<0.05	P<0.05
MUFA	38.97	40.88	41.33	40.56	NS	NS
PUFA	16.78	10.66	8.50	4.81	P<0.05	P<0.05
n-6	14.05	8.66	7.02	4.12	P<0.05	P<0.05
n-3	2.59	1.85	1.48	0.69	P<0.05	P<0.05
n-6/n-3	5.71	5.28	4.82	5.08	NS	NS
PUFA/SFA	0.39	0.22	0.17	0.08	P<0.05	P<0.05
At*	0.61	0.80	0.51	0.98	P<0.05	P<0.05

- Each value is the average of 10 samples (n=10).
- At*: Atherogenicity index calculated according to Ulbricht and Southgate (1991) whose formula is: (4*C14: 0 + C16: 0)/ (PUFA + PUFA).

Whatever the type of muscle, cooking led to a significant increase ($P < 0.05$) in the content of palmitic acid (C16:0) which increased from 22.40% to 25.57% after cooking in the leg with a difference of 12% and from 25.35% to 25.97% for the

rib after cooking, with a difference of 2.38%. In addition, this heat treatment generated a significant rise ($P < 0.05$) in the rate of stearic acid (C18:0) in the leg and in the rib. This content was 17.79% for the raw leg and increased to 18.17% after cooking and from 17.83% to 22.42% for the rib after cooking, with respective differences of 2% and 20%. Concerning C16:0, we have noticed that the results concerning this fatty acid are similar to those reported by Juárez et al. (2010) Who have observed an augmentation of the concentration of C16:0 in 200 buffalo meat fat after grilling and boiling. Our results are similar to those of Prache et al. (2009) who demonstrated that grass consumption by lambs induces an increase in the content of stearic acid (C18:0) (+ 7.9%, $P < 0.05$), a neutral or even beneficial saturated fatty acid from the point of view of the impact on cardiovascular diseases in humans. In the same context, Bauchart et al. (2010) found that frying or roasting type cooking induces a significant increase in the SFA content of rump steak (+1.5 to +1.7 g/100 g of dry tissue for the "frying" treatment and +0.5 to +0.8 for the “roasted” treatment).

On the other hand, no significant effect of cooking and the nature of the muscle on the content of monounsaturated fatty acids (MUFA) was recorded (Table 1). After cooking, the MUFA content increased in the lamb, from 38.97% to 41.33% after cooking, i.e., a difference of 5.71%. However, this MUFA rate remained globally unchanged in the coasts. Furthermore, oleic acid (C18:1 n-9) was the best represented among the monounsaturated fatty acids identified in the two muscles studied (*Biceps femoris* and *Longissimus dorsi*) (Table 1). Interestingly, cooking showed no significant effect on oleic acid levels; this content was 34.37% in the raw leg to reach 37.12% after cooking with a difference of 7.40%. As for the rib, the proportion of oleic acid released, which was 36.19% before cooking, increased to 36.67% after cooking, resulting in a gain of about 1.30%. The statistical study showed that the nature of the muscle as well as the cooking have a significant effect ($P < 0.05$) on the content of the two muscles in polyunsaturated fatty acids (PUFA) (Table 1). As for saturated fatty acids, but to a lesser degree, the content of monounsaturated fatty acids, the second major family of fatty acids in meat, tends to increase after cooking. Our results corroborate those of Bauchart et al. (2010) who found that roast and braised type cooking leads to an increase in MUFAs in beef. However, the work of Vautier et al. (2010) on pork meat revealed that cooking causes a non-significant decrease in the level of MUFAs which, from 49% in raw meat, drops to 47% after cooking at 75°C.
Concerning the effect of the nature of the muscle, the PUFA content is more accentuated in the leg than in the rib either before or after cooking. The rate of PUFAs was 16.78% in the raw leg of rib against 10.66% in the raw side, a difference of 36.47%. Similarly, the PUFA content released in the cooked leg exceeded that of the cooked rib by about 2 times (8.50% Vs 4.81% with a difference of 43.41%). Heat treatment by cooking resulted in a significant loss ($P < 0.05$) of PUFA in both muscles. From 16.78% in the raw leg, the PUFA content fell to 8.50% after cooking, resulting in a 49.34% decrease. The same trend is observed for the rib, the rate of PUFA released, which was 10.66% before cooking, reached 4.81% after cooking inducing a loss of 54.87%. These results are in agreement with those of Jacques et al. (2008) who revealed that the meat from lambs having consumed grass is rich in PUFAs, in particular those of the n-3 and n-6 series. The proportion of PUFAs destroyed during cooking increases with the number of fatty acid double bonds (Kim, 1989). According to El Affifi et al. (2011), meat from pasture is all the richer in n-3 PUFAs than that obtained from lamb having received concentrate (133 mg vs. 51 mg/100g). These levels relate to the richness of the grass in n-3 FA and the loss of n-3 PUFAs during the biohydrogenation process.

The analysis of variance shows that the cooking and the type of muscle have a significant effect ($P < 0.05$) on the content of linoleic acid (C18:2) and linolenic acid (C18:3) of the leg and the rib (Table 1). Regarding the leg, the proportion of linoleic acid was 9.14% before cooking and dropped to 5.07% after cooking, i.e. a drop equivalent to 44.52%. As for the rib, the same observations can be recorded from which we note a 39.75% drop in linoleic acid after cooking (5.71% vs. 3.44%) (Table 1). With regard to linolenic acid, the rib saw an increase of around 85.24% after this heat treatment (0.09 vs. 0.61%) (Table 1). The same observations are valid for the lamb with a C18:3 n-3 rate estimated at 0.10% before cooking and increasing to 0.94% after cooking, i.e. a gain of 89.36%. The high proportion of linoleic acid (C18: 2 n-6) in the lambs in our experiment can be attributed to an interesting intake of PUFA (mainly C18: 2 n-6) from grass (Geay et al., 2002). Moreover, the proportion of linoleic acid (C18:2 n-6) and linolenic acid (C18:3 n-3) remained higher in the leg than in the rib, either before or after cooking. However, cooking resulted in a loss ($P < 0.05$) of linoleic acid (C18:2 n-6), while this same heat treatment caused a significant increase in the content of linolenic acid (C18:3 n-3). These results agree with those of Bauchart et al. (2010), who revealed that “braised” type cooking of the chuck leads to a significant increase in linolenic acid (C18:3 n-3) (+0.06 to 0.09 g / 100 g dry tissue).

As for conjugated linoleic acid C18:2 (n-6t) (CLA), the lamb saw an increase of around 64.86% after cooking (0.13 vs. 0.37%) (Table 1). The same findings are detected for the rib with a C18:2 (n-6t) rate estimated at 0.26% before cooking and increasing to 0.30% after cooking, i.e., a gain of 13.33%. The results of our work have revealed that conjugated linoleic acid (CLA: C18: 2 n-6t) is in significant proportion in the two muscles studied (raw and cooked) with contents between 0.13 and 0, 37%. Our results are similar to those of Rondia et al. (2003) who found that grass-fed lambs have high proportions of CLA. The same results were observed in the study conducted by Jacques et al. (2008), who demonstrated that grass-fed lambs have meat richer in CLA (C18:2 n-6t) than lambs fed concentrates. ($P<0.0001$). According to Pariza et al. (2004), CLAs of cis-9 and trans-11 conformation can reduce the risk of cardiovascular disease. This trend is also valid for arachidonic acid (C20:4 n-6), regardless of the type of muscle studied, from which there was a significant drop following cooking, namely 59.79% (3.93% before cooking vs. 1.58% after cooking) and 82.46% (2.11% before cooking vs. 0.37% after cooking) for lamb and for the rib respectively (Table 1). This observation also lets us

suggest that this AG is more important in the leg than in the rib, even after cooking. The research studies conducted by Kim. (1989) on the oxidation of PUFAs during cooking, demonstrated that in chicken "label" 20% to 50% of arachidonic acid (C20:4 n-6) disappears during cooking. This observation corroborates our results where losses were estimated at 60% in the leg and 82% in the rib after cooking.

The n-6 PUFAs before or after cooking seem to be more represented in the leg muscle than in the rib. However, for this group of PUFAs, cooking exerts an unfavorable effect on their concentrations, from which a significant drop ($P < 0.05$) of the order of 50% (14.05 before cooking vs. 7.02 after) and 52.42% (8.66 before cooking vs. 4.12 after) was observed in the leg and in the rib, respectively (Table 1). The effect of cooking is also exerted on n-3 PUFAs. A significant decrease ($P < 0.05$) of approximately 43 (2.59% before cooking vs. 1.48 after) and 63% (1.85% before vs. 0.68 after) was noticed following cooking in the leg and the rib. Our study revealed that the cooking as well as the nature of the muscle have a significant influence ($P < 0.05$) on the levels of these fatty acids in the lamb and in the rib. Heat treatment caused a decrease ($P < 0.05$) of n-6 and n-3. These results agree with those of Bauchart et al. (2010) for whom “frying” and “grilling” type cooking of beef causes a decrease ($P < 0.05$) in n-3 and n-6 PUFAs. The decrease in n-6 and n-3 series PUFAs during heat treatment can be explained by their oxidation.

The n-6/n-3 ratio was not affected by cooking in the leg and the rib respectively (Table 1). This ratio remained higher, but not significant in the cooked rib (5.08%) compared to the cooked leg (4.82%) i.e. a difference of 5.11%. Our results go hand in hand with those of Rondia et al. (2003) who noted that grazing leads to a decrease in the n-6/n-3 ratio (between 4.5 and 5) in Belgian lamb meat, which remains favorable for consumer health. It is obvious that during cooking, the muscles are enriched with lipids. It is therefore not surprising to find that SFAs, MUFAs and PUFAs are directly proportional to the amount of lipids gained or lost during cooking. In our study, the n-6/n-3 ratio was 5.28 in the cooked leg and 5.08 in the cooked rib. In other words, it remained low according to Raes et al. (2004) who reported that ruminant meats have a notably low ratio of n-6: n-3 PUFA, especially when sourced from animals that have consumed grass containing high levels of 18:3.

Finally, the PUFA/SFA ratio was affected simultaneously under the effect of the nature of the muscle and the cooking. It is noted that this ratio was significantly higher in the leg than in the rib with a difference of 43.58% before cooking and 53% after cooking (0.39 vs. 0.22 before cooking and 0.17 vs. 0.08 after) (Table 1). The results obtained through our research revealed that the PUFA/SFA ratio was even higher in the leg than in the rib, either before or after cooking (0.39 vs. 0.22 and 0.17 vs. 0.08). This is due to the richness of the ribs in saturated fatty acids, because the higher the proportion of SFAs, the more the PUFA/SFA ratio tends to decrease. It is noted that lamb had a PUFA/SFA ratio equal to 0.39 and remained very close to that recommended by nutritionists, which is around 0.4 (Kouba et al., 2002).

Conclusion

The purpose of this experiment was to characterize the local lamb meat from pasture in the steppe region of Oum el Bouaghi and souk Ahras and to highlight the effect of heat treatment on the main nutrients of the meat, mainly on lipids and fatty acids. The detailed analysis carried out on raw and cooked meat allowed us to establish very clear differences between the two types of muscle studied (leg and rib).

The two muscles studied were characterized by their different lipid contents. Indeed, total lipids appeared in relatively high proportions in the *Longissimus dorsi* muscle than in the *Biceps femoris* muscles (17.01% vs. 2.62% before cooking; 19.65% vs. 7.19% after cooking), respectively.

As for fatty acids, their compositions, between the two muscles studied, were different (*Biceps femoris* and *Longissimus dorsi*). Indeed, the rib contained a higher proportion of SFA and a relatively low proportion of MUFA than those of the leg. These differences in fatty acid composition can be explained by the intervention of the nature of the muscle whose FA level varied considerably according to the anatomical site of the meat.

In our experiments, very clear differences between the two muscles appeared after cooking. Whatever the nature of the muscle, roast-type cooking resulted in a gain in SFA (44.24% vs. 50.16% leg after cooking and 48.45% vs. 54.61% rib after cooking) and in MUFA (38.97% vs. 41.33% for the leg after cooking and 40.56% vs. 40.88% for the rib after cooking). However, we noticed that both muscles lost PUFAs after cooking. These losses can be explained by the oxidation of PUFAs during cooking.

Finally, and through these results, we are allowed to think that lamb meat from the region of Oum el Bouaghi and Souk-Ahras would be a very important source of nutrients essential to the nutritional needs of Man. The choice and mastery of the method of cooking the meat is a necessary operation in order to preserve the best qualities of the meat

References

1. Bauchart D, Thomas A. 2010. Facteurs d’élevage et valeur santé des acides gras des viandes. Muscle et Viande de Ruminant, Editions Quae, pp. 131-142. Bauchart D et Picard B et Coordinateur. c/o Inra, RD 10, 78026 Versailles Cedex, France.

2. Bauchart. D, Thomas A, Durand D, Parafita E. 2010. Qualité nutritionnelle des lipides et acides gras des viandes bovines ww: Influence des conditions de cuisson des viandes. Viandes Prod. Carnés 28 (4) : 117-124.
3. Dozias D, Picard B. 1997. Caractérisation de l'aptitude à valoriser l'herbe et étude des caractéristiques musculaires en race Blonde d'Aquitaine. 4e journées 3R Rencontre Recherches Ruminants. pp 321. 4 et 5 Décembre 1997 Paris France.
4. El Affifi M, Bouderoua K, Mourot J. 2011. Effet de la cuisson sur les lipides et la composition en acides gras de la viande d'agneau d'herbe. 9es Journées Francophones de Nutrition. pp. S82. 7, 8 et 9 Décembre 2011 Reims France.
5. Folch J, Lees M, Sloane-Stanley G H 5. 1957. A simple method for the isolation and purification of total lipids from animal tissues. Journal of Biological Chemistry 226 : 497-509.
6. Geay Y, Bauchart D, ,Hocquette J F, Culioli J. 2002.valeur diététique et qualité sensorielle des viandes des ruminants. Incidence de l'alimentation sur les animaux. Revue INRAE Productions Animales: 35-52.
7. Hedwing S C. 2006. Pourquoi la viande a-t-elle si bon gout. 7eme symposium « la viande dans l'alimentation : Viande et gras». pp.43-48. 15 Novembre 2006 kultur-casino Berne.
8. Jacques J, Villeneuve L, Méthot H. 2008. Valorisation des ressources fourragères chez les agneaux à l'engraissement, Rapport d'Etape N°01, Projet n. 6223. Centre d'expertise en production ovine du Québec (CEPOQ) Univérsité Laval Canada.
9. Juárez M, Failla S, Ficco A, Peña F, Avilés C, Polvillo O. 2010. Buffalo meat composition as affected by different cooking methods. Food and Bioproducts Processing 88: 145-148.
10. Kardjadj M, Dachung Luka P. 2016. Current Situation of Milk and Red Meat Industry in Algeria. Journal of Nutrition & Food Sciences 6 : 1-3.
11. Kim E K. 1989. Contribution à la connaissance de la fraction lipidique du muscle chez le poulet: Influence des types métaboliques et contractile « Conséquence des traitements thermiques », Thèse de Doctorat en Sciences biologiques et fondamentales appliquées, : pp.14, 17-25, 95. Univérsité de Nante, France .
12. Kondjoyan A, Peyron A. 2006. Comment modéliser la cuisson de la viande- présentation des études préliminaires sur les transferts chaleur-matière. 11ème « Journée Science du Muscle et Technologie des Viandes ». pp.247-248. 4 et 5 Octobre 2006. Clermont-Ferrand, France.
13. Kouba M, Enser M, Whittington F M, Nute G R, Wood J D. 2002. Effet d'un régime riche en acide linolenique sur les activités d'enzymes lipogéniques, la composition en acides gras et la qualité de la viande chez le porc en croissance. 9ème journée des sciences des muscles et technologies de la viande.pp.63-64. 15 et 16 Octobre 2022. Clerement Ferrand France.
14. Morisson W, Smith M L. 1964. Transmethylation des lipides par chromatographie en phase gaz. Lipid 5: 600-608.
15. Mourot J, Guillevic M, Mounier A, Kerhoas N, Weill P. 2006. Effet de la cuisson ou de la transformation sur la teneur en acides gras n-3 de quelques produits animaux. 11ème « Journée Science du Muscle et Technologie des Viandes ». pp.99-100. 4 et 5 Octobre 2006. Clermont-Ferrand, France.
16. Nikmaram P, Yarmand M S, Emamjomeh Z. 2011. Effect of cooking methods on chemical composition, quality and cook loss of camel muscle (Longissimus dorsi) in comparison with veal. African Journal of Biotechnology Vol. 10(51) : 10478-10483.
17. Pariza M W. 2004. Perspective on the safety and effectiveness of conjugated linoleic acid. American Journal of Clinical Nutrition 79: 1132S-1136S.
18. Prache S, Ballet J, Jailler R, Meteau K, Picard B, Renerre M, Bauchart D. 2009. Comparaison des qualités de la viande et de la carcasse d'agneaux produits en élevage biologique ou conventionnel. Innovations Agronomiques 4 : 289-296.
19. Prusa K J, and Lonergan M M. 1987. Cholesterol content of broiler breast filets heated with and without the skin in convection and conventional ovens. Poultry Science 66 : 990-994.
20. Rabot C. 1998. Vitesse de croissance et caractéristiques lipidiques et sensorielles des muscles de poulet. Thèse de 3è cycle, Institut national agronomique Paris-Grignon, France.
21. Raes K, Haak L, Balcaen A, Claeys E, Demeyer S and De Smet S. 2004. Effect of linseed feeding at similar linoleic acid levels on the fatty acid composition of double-muscled Belgian blue young bulls. Meat Sci 66: 307-315.
22. Rondia P, Delmotte C, Dehareng F, Maene D, Toussaint J F N, Artiaux-Thill B. 2003. Incidence d'un apport en graines de lin chez la brebis et l'agneau sur les performances et le profil en acides gras de la viande d'agneaux élevés en bergerie ou au pâturage. 10e journées 3R Rencontre Recherches Ruminants. pp P227-230. 3 et 4 Décembre 2003 Paris France.
23. Santé-Lhoutellier V, Astruc T, Marinova P, Grève E, Gatellier P. 2008. J. Agric. Food Chem 56: 1788-1494.
24. Vautier A, Carlier M, Martin J L, Gault E, Vendeuvre J L. 2010. Impact de la cuisson et de la température à cœur sur les valeurs nutritionnelles du rôti filet de porc. 42e Journées de la Recherche Porcine. pp.225-226. 2 et 3 février 2010 Paris France.