African Journal of Biotechnology Vol. 9 (29), pp. 4631-4637, 19 July, 2010
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2010 Academic Journals

*Full Length Research Paper*

# Growth performances, carcasses parameters and meat fatty acid composition of lamb fed green oak acorns (*Quercus ilex*) based diet

**Ramdane Keddam, Kaddour Bouderoua*, Mohamed El-Affifi and Ghalem Selselet- Attou**

Laboratory of Food Technology and Nutrition, University of Mostaganem, BP 300. Mostaganem (27000), Algeria.

Accepted 28 May, 2010

**The aim of this experiment is to compare the effects of diets containing green oak acorns (GO) and barley (BL) on the growth performances, carcasses parameters and the composition in fatty acids of lambs. Two groups of five lambs each were fed, respectively, during 105 days with diets containing 50% of oaks acorns and 50% of barley. At the end of the test, the animals of the two diets expressed comparable body weights and weight gain. A significant difference ($P < 0.05$) was observed for the thickness of fat cover which is 3 mm for the BL group against 1.6 mm for GO group even if no significant difference was revealed concerning the output with slaughtering. The intramuscular lipids were significantly higher ($P < 0.05$) in the group of animals fed with GO diet compared to the BL diet (3.88 vs 2.83 $g.100^{-1}$ g of muscle). Among the saturated fatty acids (SFA), the stearic acid significantly appeared in higher proportion ($P < 0.05$) in GO diet (20.8 vs 18.1%) whereas the palmitic acid is prevalent in the group of animals fed with the BL diet (25 vs 30%). For the polyunsaturated fatty acid (PUFA), no significant difference was observed between the two groups. The linoleic acid is prevalent among the PUFA of two groups without significant difference. The linolenic acid is higher in the animal fed BL. The n-6: n-3 ratio is higher in the BL group (8.9 vs 7.3). At the end, the low level of incorporation of PUFA in muscle of the lamb because of biohydrogenation, suggests us supplementing the diet by green grass.**

**Key words:** Meat, lamb, oak acorn, barley, fatty acid.

## INTRODUCTION

Representing a surface of more than 634.000 ha, the green oak (*Quercus ilex*) is one of the forest trees with multiple virtues of the Algerian forest. However, the exploitation of the fruit of this tree in animal feeds remains in an embryonic state. The research works carried out on the valorization of this food product in animal feeds characterizing its wealth in energy and unsaturated fatty acids is a prospect resulting from an economic and nutritional need which should lead to a broad use of this forest product by the poultries and the small ruminants.

The physicochemical data available on this food product show a wealth of starch (44 to 59%; Kekos and Kaukios, 1985) and unsaturated fatty acids, especially oleic and linoleic acids (Ofcaric and Burns, 1971; Lopes and Bernardo-Gil, 2005) a variable content of tanins according to the areas and climates (Rakié et al., 2007) allowed its use in animal feeds, like pig and broilers chickens (Bouderoua and Selselet-Attou, 2003; Rey et al., 2005; Bouderoua et al., 2009).

Studies have been undertaken on the quality of meats, for which the nutritionists are interested to limit its harmful

*Corresponding author. E-mail: Bouderoua.kad@voila.fr. Tel: +213 7 75 37 79 23.

**Abbreviations: GO,** Green oak acorns; **BL,** barley; **SFA,** saturated fatty acids; **PUFA,** polyunsaturated fatty acids; **BW,** body weights; **DM,** dry matter; **TL,** total lipids; **WG,** weight gain; **EW,** eviscerated weight; **MUFA,** monounsaturated fatty acid.

effects on human health. Indeed, it is established that the meat fatty acids composition is largely influenced by the dietary lipids (Mourot and Hermier, 2001). Thus, in chicken, the saturated lipids like copra oil and palm oil increase the proportions of fatty acids with short chain; animal fats (tallow and lard) enrich the lipid deposits with saturated fatty acids (SFA). Conversely, vegetable oils rich in polyunsaturated fatty acids (PUFA) in Colza, Soya or Flax increase their content in meat (Mossab, 2001). However, in sheep, the situation is very different because of trans-isomerization phenomenon of PUFA in the rumen during the process of bio-hydrogenation. Vossemberg and Joblin (2003) and Boles et al. (2005) reported that the bacteria's rumen, are able to transform directly the alpha linoleic acid into stearic and palmitic acids. With this specificity, the dietary contributions rich with PUFA largely influence the proportions of linolenic acid of ruminant's meats (Wachira et al., 2002; Meane et al., 2002). In fact, the introduction of the linseed into the diet of lamb in growth significantly increased C18:3 in the meat (Normand et al., 2007). In the same way, Nurnberg et al. (1998) found that the fat supply increases the quantity of C18:3 and their counterparts of long chain in the lamb with proportions multiplied by 2.4 for C18:3; 3.5 for C20:5 and 1.8 for C22:5. Geay et al. (2002) reported that the carcasses of lambs raised with the pasture presented a higher percentage in C18:3 in their muscles compared to those with diets containing concentrates.

The purpose of this work is to test the possibilities that offers a diet containing acorn of green oak (*Q. ilex*) in comparison with another based on barley on the growth performances and fatty acids composition of lamb meat.

## MATERIALS AND METHODS

### Animals and diets

Ten lambs (five per diet) of local race "Ouled Djellal", having an average weight of 32.3 ± 1.65 kg of six months old were divided into two groups of five and fed for 105 days. Two diets, one based on barley (BL), the second containing green oak acorn (GO) were distributed twice a day at a rate of 400 g/animal/day. Acorn consisted on the whole fruit collected at the end of November 2008. To ensure safer and longer storage of experimental diet, acorn was incorporated into diet after being air-dried in the shade for 25 days and ground using a local commercial grain mill fitted 4 mm pore size sieve. The ingredients and the physicochemical composition of both diets are illustrated in Table 1 and fatty acid composition in Table 2. The body weights (BW) were measured each week by weighing the animals.

### Measurements at slaughter

At the end of the test (105 days), the lambs of each diet were killed, processed, and eviscerated in a local commercial slaughterhouse. After evisceration, the lambs were apportioned by hand. After 24 h of sweating in a cold room at +6°C, the measurements were operated for the appreciation of thickness of cover fat at the sternum position. Samples (100 g) of *Femoris* muscle were obtained at the left leg. Meat samples from each animal were placed in plastics bag and frozen at -20°c until analysis. Abdominal adipose tissue were also removed and weighed individually.

**Table 1.** Composition of the diets.

| Ingredients (%) | BL | GO |
|---|---|---|
| Barley | 50 | 0 |
| Oak acorns | 0 | 50 |
| Soya bean meal | 32 | 32 |
| Bran of wheat | 15 | 15 |
| Calcium and phosphorus | 3 | 3 |
| **Analyzed composition ( g / 100 g)** | | |
| Dry Matter | 86.9 | 86.56 |
| Mineral matter | 10.20 | 9.26 |
| Crud protein | 19.68 | 18.22 |
| Lipids | 2.56 | 6.50 |
| Crude fiber | 9.50 | 11.16 |
| Starch | 54.00 | 49.00 |
| Calculated Net energy ( kcal/ kg) | 1468.74 | 1506.40 |

**Table 2.** Fatty acids composition of diets (in % of identified fatty acids).

| Diets | BL | GO |
|---|---|---|
| C14:0 | 0.09 | 0.28 |
| C16:0 | 13.28 | 18,.04 |
| C16:1 n-7 | 0.31 | 0.33 |
| C18:0 | 3.24 | 2.77 |
| C18:1 n-9 | 56.05 | 17.82 |
| C18:2 n-6 | 24.31 | 54.65 |
| C18:3 n-3 | 1.28 | 4.19 |
| C20:0 | 0.34 | 0.26 |
| C20:1 n-9 | 0.83 | 1.01 |
| C20:3 n-3 | 0.15 | 0.21 |
| C24:0 | 0.13 | 0.39 |
| C24:1 n-9 | 00.00 | 0.05 |
| SFA | 17.07 | 21.74 |
| MUFA | 57.19 | 19.21 |
| PUFA | 25.74 | 59.05 |
| n-3 | 1.42 | 4.40 |
| n-6/n-3 | 17.07 | 12.43 |

### Laboratory analysis

### Analysis of diets

Samples of diets were dried and stored for subsequent analyses. The dry matter (DM) was obtained using the drying oven at 103°C for 24 h and mineral contents was determined by ashing at 600°C for 8 h. Nitrogen was determined according to the Kjeldahl method

**Table 3.** Growth performances and carcass characteristics.

| Diets | BL | GO | Dietary effect |
|---|---|---|---|
| Body weight (kg) | 42.02±3.30[a] | 41.64±0.37[a] | NS |
| Gain Weight (g/ week) | 681 ± 41[a] | 650 ± 82[a] | NS |
| Eviscerated carcass weight (Kg) | 19.36 ± 1.40[a] | 18,66 ± 0.83[b] | <0.05 |
| Carcass yield (%) | 46.12 ± 2.10[a] | 44.82 ±1.92[b] | <0.05 |
| Abdominal fat weight (Kg) | 0.60 ± 0.14[a] | 0.64 ± 0.11[a] | NS |
| Cover fat thickness (mm) | 3.00±1.5[a] | 1.60±0.5[b] | <0.05 |

n = 5; Results expressed as mean and standard deviation; means in the same line with different superscripts are significantly different; NS: not significant.

**Table 4.** Chemical composition of meat (g /100 g of muscle).

| Diet | BL | GO | Dietary effect |
|---|---|---|---|
| Dry matter | 29.0 1± 6.70[a] | 27.50 ± 4.47[b] | <0.05 |
| Mineral matters | 2.74 ± 0.23[a] | 2.84± 0.77[a] | NS |
| Proteins | 19.16 ± 1.85[a] | 17.27± 0.77[a] | NS |

n = 5; Results expressed as mean and standard deviation; means in the same line with different superscripts are significantly different.

(AOAC, 1990). The crude fiber was given according to the method of Vansoest et al. (1991). The starch was determined according to the polarimetric method of AOAC (1990).

#### Analysis of meats

Total lipids (TL) of each sample (diet or meat) were extracted by chloroform-methanol (2:1) according the method of Folch et al. (1957). Fatty acid (FA) of lipids were freed by saponification (NaOH), and then methylated by methanol–$BF_3$ (Morison and Smith, 1964). The methylic esters of FA were separated and quantified by gas chromatograph (Perkin -Elmer AutoSystem XL) equipped with flame ionization detector and a capillary column (30 m x 0.25 mm internal diameter). The operating conditions of the gas chromtograph were as follow: injector and detector temperature of 220 and 280°C respectively. The oven temperature was programmed 45 - 240°C, with 20 - 35°C $min^{-1}$. Aliquots of 1 µl were injected with bicyanopropyl phenyl silicone as a stationary phase. Hydrogen was used as conductor gas. FA peaks were identified by comparison with retention times of fatty acids methyl standards. Quantification was made by an internal standard (C17:0).

#### Statistical analyses

Data were analyzed using statistical analysis system (SAS) software (GLM procedure, SAS institute, 1989) and were expressed as mean and standard deviation (SD). Parametric values were compared with one way analysis of variance (ANOVA) and Bonferroni's tests. The level ($P<0.05$) was considered as the cut-off for significance.

## RESULTS

### Productive performance

BW and weight gain (WG) values are presented in Table 3. During the 105 days of test, the WG observed between the two groups of lambs were comparable, (681 vs 650 g /week). With the same levels of ingestion and comparable contents of net energy (1468 and 1506 kcal, table 1), the two diets generated the same effects on the growth of lambs.

### Carcass parameters

The carcass parameters are shown in Table 3. The eviscerated weight (EW) and carcass yield from lambs fed on GO reached a low final result weight compared to the control ($p < 0.05$). The same observation was valid for the cover fat thickness ($p < 0.05$) (3 mm of BL group vs 1.6 mm of GO group). However, no significant difference ($P < 0.05$) was observed for the abdominal fat weight.

### Biochemical composition of meat

Concerning the mineral matters and proteins, no significant difference was revealed between the two groups (Table 4). However, the content of the dry matter exhibited in the meat of animals fed GO diet was significantly lower ($P < 0.05$) compared to that of the animal's control BL (27.7 vs 29.0%). The level of intra muscular lipid (Table 4) was significantly higher ($p < 0.05$) in the lambs fed GO than in those fed BL (3.88 vs 2.88 g /100 g). The fatty acids composition meat (table 5) showed a prevalence of palmitic, stearic, oleic and linoleic acids. The stearic acid content was in higher proportion ($P < 0.05$) in meat of animals of GO diet. On the other hand, palmitic

**Table 5.** Total lipids (g/ 100 g of muscle) and fatty acids composition (in % of the identified FA) of femoris muscle fed oak acorns and barley based diets.

| Parameters | BL | GO | Dietary effect |
|---|---|---|---|
| Total lipids (g/ 100g) | 2.83 ± 1.4[a] | 3.88 ± 2.57[b] | <0.05 |
| C14:0 | 3.55±1.3[a] | 3.46±1.32[a] | NS |
| C16:0 | 25.50 ± 1.2[a] | 23.67 ± 1.26[b] | <0.05 |
| C14:1 | 0.55±0.29[a] | 0.64±0.19[a] | NS |
| C18:0 | 18.19 ± 1.41[a] | 20.87 ± 1.34[a] | 0.05 |
| C16:1 n-7 | 3.19±0.32[a] | 2.98±0.36[a] | NS |
| C18:1 n-9 | 41.05 ± 2.59[a] | 39.93 ± 1.91[a] | NS |
| C18:2n-6 | 5.27 ± 0.76[a] | 5.52 ± 1.68[a] | NS |
| C18:3n-3 | 0.37 ± 0.14[a] | 0.42 ± 0.06[a] | NS |
| C20:0 | 0.15±0.04[a] | 0.15±0.04[a] | NS |
| C20:1 n-9 | 0.80±0.32[a] | 0.81±0.20[a] | NS |
| C20:4n-6 | 0.94 ± 0.31[a] | 0.90 ± 0.69[a] | NS |
| C20:5n-3 EPA | 0.07 ± 0.034[a] | 0.08 ± 0.05[a] | NS |
| C22:5n-3 | 0.21 ± 0.10[a] | 0.26 ±0.10[a] | NS |
| C22:ñ-3 DHA | 0.05 ± 0.03[a] | 0.09 ±0.04[a] | NS |
| C24:1 n-9 | 0.17±0.03[a] | 0.13±0.03[a] | NS |
| SFA | 47.34 ± 2.31[a] | 48.15 ± 2.53[a] | NS |
| MUFA | 45.76 ± 1.5[a] | 44.49 ± 1.42[a] | NS |
| PUFA | 6.91 ± 1.13[a] | 7.35 ± 2.64[a] | NS |
| n-6/n-3 | 8.97 ± 1.29[a] | 7.37 ± 1.46[a] | NS |
| PUFA/SFA | 0.15± 0.06 [a] | 0.15± 0.04[a] | NS |
| n-3 | 0.86 ± 0.16[a] | 0.76 ± 0.23[a] | NS |
| Index of unsaturation[1] | 1.19±0.02[a] | 1.21±0.03[b] | <0.05 |

n = 5; Results expressed as mean and standard deviation; means in the same line with different superscripts are significantly different; NS: not significant; [1]Index of unsaturation according to Girard et al. (1985), calculated as: [1(C16:1 + C18:1) + 2(C18:2) + 3 (C18/3)] / [(C16:1 + C18:1 + C18:2) + (C18:3)].

acid was higher (P < 0.05) in animals of control group than those on GO diets (25 vs 23%) and the myristic acid proportion was comparable between the two groups. The content of SFA was equivalent between the both groups (47 and 48%). Monounsaturated fatty acid (MUFA) showed the greatest level for both meat; oleic acid being the predominant constituent (41 and 40%), followed by palmitoleic acid (3.19 and 2.89%). The difference between the two dietswas not significant.

Linoleic acid showed comparables proportions in meats of both groups (5.52 and 5.27%). Compared to the whole of PUFA, it accounted for 76.3 and 75.1% for GO and BL groups, respectively. However, the linolenic acid of BL's animals was higher (P < 0.05) than that of GO animals (0.42 vs 0.37 %). Among the PUFA long chain, the prevalent FA is C20:4 n-6 (0.94 vs 0.90%); C22:5 n-3 (0.21 vs 0.26%). The C20:0 and C20:1 n-9 present in diets, was found in appreciable quantities in meats. On the other hand, five among PUFA long chain absent from diets (C20:2; C20:4; C24:1 n-9; C22:5 n-3 and C22:6) were found in the meats of the two groups. The n-6 /n-3 ratio in the meat of GO group was lower than that in the BL diet (7 vs 9%). PUFA: SFA ratio was equivalent in two groups (0.15 in both groups). The lipid unsaturation index in GO group was significantly higher (p < 0.05) than the one of BL group (1.21 vs 1.19).

## DISCUSSION

No significant difference was observed for the growth performances. However, the lambs fed GO diet at the beginning of the test, presented a speed growth slightly lower than those fed BL diet. It is possible that the high content of fat in GO diet (6.5 Vs 2.5%) affected the growth of lambs. According to Gadoud et al. (1992) and Normand et al. (2005), the percentage of lipids in ruminants diets is limited to 5%. These authors confirmed that the dry matter degradation was weaker with diets enriched with fat. In the same way, Rondia et al. (2003) reported that the growth can be affected by the high content of dietary fat which disturbs the rumen functioning. Ultimately, and in spite of these factors which can affect the digestive use of the diet, the absence of significant difference between the final weights of lambs of the two groups indicated that those fed GO diet have an

equivalent nutritional aptitude than the BL diet.

In the carcass of animal's GO diet, the low thickness of subcutaneous fat may be explained by starch quality of oak acorn which contributed to the inhibition of lipogenesis and it appeared that the high lipids content of GO diet (6.5 vs 2.5%) did not contribute to increasing the cover fat. This observation corroborates Normand et al. (2005) indicating that the lipidic contribution even higher than 5% in diet does not appeared to have a high incidence on the thickness of cover fat. However, in spite of the difference observed between the subcutaneous fats of the two groups, the fat thickness observed remains in the recommended standard (1 - 3 mm) constituting an optimum for the carcasses. Indeed, Debrot and Constantin (1968) recommended that it should not exceed 5 mm.

The dry matter and mineral matters contents appeared relatively higher in animals of both groups. Gruszecki et al. (1999) reported 25.5% for the dry matter and 1.05% for mineral matter in goat meat. The proteins content of meat of the BL group was higher compared to GO diet but equivalent to that given by Gruszecki et al. (1999) which is 19.30%. The intramuscular lipids observed in the leg of GO were higher than those mentioned in the BL diet (3.88 Vs 2.83%). These results appeared relatively comparable with research of Chesneau et al. (2004) with linseed based diet which allowed increasing the intramuscular lipids of the young bovines Charolais from 3.2 - 3.7%. According to Tshabalala (2003) and Bas et al. (2005), these intramuscular lipidic contributed to a better nutritional quality. In this context, Chesneau et al. (2004) reported that the nature of diet influences the rate of muscular lipids. In lambs fed GO diet, the increase of the quantity of available energy of diet affected the abdominal fat (about 27%). Our results corroborate those obtained on the kids of local race of South-West of Morocco (Bas et al., 2005).

The contents of SFA observed in meat of the two groups were lowers than the rate of 50% reported by CIV 1996 (centre d'information des viandes, France) in muscle of lamb and beef, but there were comparable with those reported by Chesneau et al. (2004) found with young bovines. The high rates observed in this test were explained by bio-hydrogenation process in rumen of unsaturated fatty acids into SFA. The proportions in oleic acid observed at the two groups were comparable with those reported by Chesneau et al. (2004) on white bovines fed a diet enriched with 5% of extruded linseed, but relatively lower than young bovines Charolais. Comparables results were observed by Bas et al. (2005) on kids fed leaves of argane and receiving 40% of corn as concentrate. Within this framework, we are tempted to bring back the results Bouderoua et al. (2009) realized on broilers fed oak acorn (*Quercus ilex*) based diet in which similarity to our results were obtained in the thigh muscle compared to the control group (41 vs 38%). In the same context, this might be explained in lambs fed the GO diet by the proportion and nature of starch less digestible than that contained in the barley. Thus, there will be less substrate for hepatic lipogenesis (Mourot and Hermier, 2000). The quantities of C20:0 and C20:1 found in the meat of GO diet compared to those in the control diet showed that they were only subjected to a weak bio-hydrogenation (Ashes et al., 1992). On the other hand, C24:0 and C20:3 were entirely hydrogenated in rumen lambs, since no trace was found in the meat of the two groups.

According to Gruszecki et al. (1999), the prevalent PUFA in meat of lambs are C18:2 n-6 and C18:3 n-3. This observation appeared clearly in lamb meat of our trial: 75 to 76% of PUFA respectively. The PUFA contents in muscles of both groups were higher compared to the content reported by Gandemer (1998) which indicated that the intramuscular lipids contain 2 - 3 % of PUFA in ruminants against 20 - 25% in broilers. Lower contents were found by Bas et al. (2005) and which varied between 1.1 and 4% realized on young goat fed with concentrate and reared on the argane pulp. The content of C18:3 n-3 obtained in the meat of GO group was in conformity with the observation of Beriane et al. (2000) which reported proportions varying between 0.42 to 1%. Their presence would result from an exogenous supply of PUFA, following the bio-hydrogenation phenomenon (Harfoot and Hazlewood, 1997). Generally, the contents of total PUFA of muscle were higher in GO group than that based on barley (7.4 and 6.9%). In this context and considering the high content of intramuscular lipids of GO group compared to the BL group (3.8 vs 2.8%), the quantitative representation of the PUFA was higher in the GO group.

In this context, Doreau and Chillard (1997) estimated that the PUFA long chain is entirely hydrogenated in the rumen. The synthesis of C20:2; C20:4; C22:5 n-3 and C22:6 n-3 (DHA) corresponds to the observations of Harfout and Hazlewood (1997) and Sauvant and Bas (2001) which reported that an endogenous synthesis of these fatty acids can be carried out starting from the short precursors such as the volatile fatty acids and glucose. The content of C20:4 n-6 observed in this trial was in agreement with those found by Sonnetag (1979) who showed that these fatty acids constitute less than 1% of bacon or tallow. Absent in both diets, C20:2 was synthesized by the rumen flora of GO diet, and was probably linked to high lipidic substrate. However, this fatty acid was not synthesized by the animals of BL diet. Generally, the PUFA long chain is uncommon in meat, which could give the impression of a very weak activity of the desaturases $\Delta 5$ and $\Delta 6$ as it clearly shown by Chesneau et al. (2004). The C20:5, C22:5 and C22:6, numerous in marine oils (Aidos et al., 2002), are also found in the muscle of leg of the two animals groups.

The n-6/n-3 ratio of 7.37 in GO group remains overall lower compared to 8.97 obtained in the BL animals and the value of 11 reported by Normand et al. (2005) for the ruminant's meat. They remained on the whole, beneficial to human health compared to the nutritional ratio equal to 5 as reported by Martin (2001). PUFA: SFA ratio equivalent

to 0.15 obtained from the meat of both groups remained very weak. This corroborates the value varying between 0.11 and 0.15 recorded by Wood and Enser (1997) in meat of bovine and lamb. This ratio remains lower than the value of 0.45 recommended for red meat in human nutrition. This can be improved by incorporating green forage in diets of lambs.

In conclusion, according to the nutritionists' recommendations concerning the n-6/n-3 and PUFA/SFA ratios, natural increase in sheep meat in unsaturated fatty acids useful for health, via feeding are advocated. The young green grass constitutes a diet naturally rich in linoleic acid (C18:3 n-3) which constitutes a good way to increase the content of these PUFA in the meat and to make it more nutritionally appealing. Green grass resources undergo a less severe hydrogenation of the C18:3 n-3.

**REFERENCES**


Aidos I, Masbernat–Martinez S, Luten JB, Boom RM, Van Derpadt A (2002). Composition and stability of Herring oil recovered from sorted by products as compared to oil from mixed byproducts. J. Agric. Food Chem. 50: 2818-2824.

Ashes JR,Siebert BD, Gulati SK, Cuthbertson AZ, Scott TW (1992). Incorporation of n-3 fatty acids of fish oil into tissue and serum lipids of ruminants. Lipids. 27: 629-631.

Association of Official Analytical Chemistry (AOAC) (1990). Official methods of analysis, 15th edition. AOAC Arlington.

Bas P, Morand Fehr P, El Aiche A, Dahbi. E, Araba A (2005). Systèmes d'alimentation, performances de croissance et qualités nutritionnelles des viandes de chevreaux élevés dans l'arganerie au sud-Ouest du Maroc. Cahiers d'Agric., 14 : 5.

Berrian MJ, Horkada A, Puroy A, Lizaso G, Chasco J, Mendizabal JA (2000). Characteristics of lacha and *Rasa aragonesa* lambs staughtered at there live weights. Jal. Anim. Sci. 78: 3070-3077.

Boles JA, Kott RW, Hatfield PG, Bergman JW, Flynn CR (2005). Supplemental Sunflower oil affects the fatty acid profile, including conjugated linoléic acid of lamb. J. Anim. Sci., 83: 2175-2181.

Bouderoua K, Selselet AG (2003).Fatty Acid composition of abdominal adipose tissue in broilers fed green oak (*Quercus ilex*) and Cork oak acorn (*Quercus suber* L.) based diets. Anim. Res. 52: 377-382.

Bouderoua K, Mourot J, Selselet AG (2009).The effect of green oak acorn (*Quercus ilex*) based diet and meat fatty acid composition of broilers. Asian-Australasian. J. Anim. Sci. 22(6): 843-848.

Chesneau G, Quemener B, Weill P (2004). Qualité nutritionnelle des lipides de viandes : Ecarts liés à l'espèce, Ecarts liés à l'alimentation: Quelques observations. Revue des viandes et produits carnés, pp. 59-60.

CIV (centre d'information des viandes) (1996). Valeurs nutritionnelles des viandes. Analyse réalisée par la compagnie scientifique de l'hygiène Street Taitbout. 75009 Paris.

Debrot S, Constantin A (1968). Hygiène et production de viande. Service vétérinaire municipal de Lausanne. Chap 29. Appréciation du bétail abattu. pp:167-182.

Doreau M, Chillard Y (1997). Effects of ruminal on post- ruminal Fish oil supplementation on intake and digestion in dairy cows. Reprod. Nutr. Dev. 37: 113-124.

Folch J, Lees M, Sloane Stanley GH (1957). A simple method for isolation and purification of total lipids from animal tissues. J. Biol. Chem., 226:497-509.

Gadoud. R, Josef MM, Jussiau R, Lisberney MJ, Mangeol B, Montmeas L, Tarrita A, Danuy JL, Drogoul C, Silk B, (1992). Nutrition et alimentation des animaux d'élevage. INRAP. Ed. Foucher p. 286.

Gandemer G (1998). Lipids and meat quality. Lypolysis oxidation and Flavour, Proc. 44th, OCo MST, Barcelona, pp. 106 -119.

Geay Y, Bouchart D, Hocquette JF, Culioli (2002). Effect of Nutritional factors on biochemical structural and metabolic characteristic of muscles in ruminants consequences one dietetic been worth and sensory qualities of meat. Reprod, Nutri. Dev. 41: 1-26.

Girard JP, Bout J, Salort D (1985). Lipides et qualités des tissus adipeux et musculaires de porc, facteurs de variations. Journées Rech. Porcines. France. 20: 255-278.

Gruszecki T, Lipecka C, Ezymanowska A, Wiercinski J, Jumkusew A (1999). Comparison of fatty acid in the intramuscular conceited of sheep and goats. Zesz Nauk Prz. Hod. 43: 87-94.

Harfoot CG, Hazelwood GP (1997). In The rumen microbial ecosystem London (UK): Elsevier Science Publishers. pp. 382-426.

Kekos D, Kaukios EG (1985). Acid hydrolisates of acorn polysacharides have substrates for *Candida utilisis* growth. Biotechnology letters. Athens, flight. 7(5): 345-348.

Lopes I, Bernardo-Gil MG (2005). Characterization of acorn oils extracted by hexane and by supercritical carbon dioxide. Europ. J. Lipid. Sci. Technol. 107(1): 12-19.

Martin A (2001). Apports nutritionnels conseillés pour la population française. Tec & Doc, 3ème édition, Paris.

Meane D, Dehareng F, Huneau Davin C, Deswyen G (2002). Influence of diet on the profile in combined linoleic fatty acids meat of lamb. Renc. Rech. Ruminants. 9: 322.

Morison WR, Smith ML (1964). Preparation of fatty acids methyl esters and dimethylacetals from lipid with boron fluoride-methanol. J. Lipid. Res. 5: 600-608.

Mossab A (2001). Effet des acides gras polyinsaturés sur les performances de croissance de la dinde et sur les effets sur la qualité de la viande. Thèse de doct. de l'Université de Tours. p. 170.

Mourot J, Hermier D (2000). Animal lipids in monogastric meat. Reprod. Nutr. Dev. 41: 109-118.

Normand J, Bastien D, Bauchart D, Chaigneau F, Chesneau G, Doreau M, Farrie JP, Joulie AR, Lepichon D, peyronnet C, Quinsac A, Renon J, Ribaud D, Turin F, Well P (2005). Produire de la viande bovine enrichie en AGPI oméga 3 à partir des graines de lin : quelles modalités d'apport du lin. Quelles conséquences sur les qualités de la viande. Renc. Rech. Rum., 12: 359-366.

Normand J, Berthelot V, Delmotte C, Pottier E, Sagot L, Dobbels M, Bas P (2007). Effet des lipides de la ration sur les performances de croissance, la qualité des carcasses et la composition en acide gras de la viande d'agneau. Renc. Rech. Rum., 14: 337-340.

Nurnberg K, Wenger J, Ender K (1998). Factors influencing fat composition in muscle and adipose tissue of farm animals. Livest. Prod. Sci. 56: 145-156.

Ofckarik RP, Burns EE (1971). Chemical and physical properties of selected acorns. J. Sci. Food Agric. 36: 576-578.

Rakić S, Petrović S, Kukić J, Jadranin M, Tesevic V, Povrenović D, Siler-Marinkovic S (2007). Influence of thermal treatment on phenolic compounds and antioxidant properties of oak acorns from Serbia. Food Chem. 104: 830-834.

Rey AI, DazaLopez-Carrasco AC, Lopez-Bote CJ (2005). Feeding Iberian pigs with acorns and grass in either free –range or confinement affects the carcass characteristics and fatty acids and tocopherols accumulation in *Longissimus dorsi* muscle and backfat. Meat Sci. 73(1): 66-74.

Rondia P, Delmotte. C, Dehareng F, Maene D, Toussaint JF, Bartiaux-Thille (2003). Incidence d'un rapport en graines de lin chez la brebis et l'agneau sur les performances et le profil en acides gras de la viande des agneaux élevés en bergerie ou au pâturage. Renc. Rech. Rum., 10: 227-230

SAS (1997). Users Guide. Statistics. Version 6-12 Edition SAS Inst., inc., Cary. NC.

Sauvant D, Bas P, (2001). La digestion des lipides chez le ruminant. INRA. Prod Anim. 14: 303-310.

Sonnetag N (1979). Structure and composition of fats and oils in swern D (Ed) baley's industrial oil and fat products., fourth edition. Wiley interscience : New York. 1: 1-98.

Tshabalala PA, Strydom PE, Webb EC, Kock HL (2003). Meat quality of disignated south african indeginous goat and sheep breeds. Meat Sci. 65: 563-570.

Vansoest PJ, Robertson JB, Lewis BA (1991). Methods for Dietary fiber, neutral détergent fiber, and non starch polysaccharides in

relation to. Animal nutrition. J. Dairy Sci. 74: 3538-3597.
Van de Vossenberg JLCM, Joblin KN (2003). Biohydrogenation of C18 unsaturated fatty acids to stearic acids by a strain of Butirvibrio hangatei From the bovine ruminant. Latt Appl. Microbiol., 37:424-428.
Wachira AM, Sinclaire LA, Wilkinson RG, Enser M, Wood JD, Fisher AV (2002). Effects of dietary fat polyunsatured fatty acid and conjugated linoleic acid content of sheep meat and adipose tissue. Brit. J. Nutr., 88:697-709.
Wood JD, Enser M (1997). Factors influencing Fatty Acids in meat and the role of antioxidant in improving meat quality. Brit J. Nut., 78: S49-60.