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Fatty Acid and Amino Acid Composition of *Pelibuey* and *Polypay* x *Rambouillet* Lambs

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Abstract: Ten male *Pelibuey* lambs (P) and 11 male *Polypay x Rambouillet* lambs (PR) were used to evaluate the breed effect upon fatty acid and amino acid profile on the *Longissimus dorsi*. Lambs were fed a diet containing 3 mega-calories of metabolizable energy and 18% of crude protein, according to NRC for lambs. They were sacrificed when reaching six months of age. *Longissimus dorsi* samples from the right side carcass of lambs were taken for fatty acid and amino acid determination and stored at-10°C until analyzed. The statistical package SPSS version 11 was used to compare the data applying a T-Student for Independent Samples (r=0.99) to establish the differences between the breeds studied against the fatty acid and amino acid profile. Racial groups did present significant differences ($P<0.01$) over the amino acid contents of *Longissimus dorsi*, arginine, tryptophan, glutamine and tyrosine, this last one being higher for *Pelibuey* lambs. Lysine and asparagine presented the highest concentrations for both lambs. Concerning fatty acids composition, there were significant statistical results ($P<0.01$) regarding breed over caproic, capric, myristoleic and palmitoleic acid, *Polypay x Rambouillet* presented higher concentrations; on the contrary *Pelibuey* had higher amounts of arachidonic acid. Nervonic acid had a remarkable concentration on both breeds.Therefore, breed had a pronounced effect over amino acid and fatty acid contents, having a better meat quality *Pelibuey* over *Polypay x Rambouillet*, although there is a small margin of difference between them.

Key words: Fatty acids · Amino acids · Lamb · *Pelibuey* · *Polypay x Rambouillet*

INTRODUCTION

Protein is essential for growth and development providing the body with energy and needed for the manufacture of hormones, antibodies, enzymes and tissues [1]. It also helps maintain the proper acid-alkali balance in the body. When consumed, it is broken down into amino acids, the building blocks of all proteins. Some of which are designated nonessential. Humans can produce ten of the twenty amino acids. The others must be supplied in the diet daily because the human body does not store excess amino acids for later use, unlike fat and starch. Failure to obtain enough of even one of the ten essential amino acids, result in degradation of the body's proteins (muscle and other tissues) to counteract the imbalance. The nutritional value or quality of structurally different proteins varies and is governed by amino acid composition, ratios of essential amino acids, susceptibility to hydrolysis during digestion, source and the effects of processing [2]. To optimize the biological utilization of proteins, a better understanding is needed of the various interrelated parameters that influence their nutritive value. Therefore, the importance of analyzing different sources of consumed protein as meat and as mentioned further on, in this document, has not yet been studied in different breeds of ovines.

Recently, in Mexico ovines are being reared because they are a good alternative as animal origin food for feeding the ever-growing world population, due to the fact that they can survive, reproduce and produce meat and/or milk under hard environmental conditions, in addition to being easier to handle than other type of cattle.

As well essential fatty acids are nutrients that must be obtained from the diet because humans lack the anabolic processes for their synthesis. There are two

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closely related groups of essential fatty acids, the ω-3 and ω-6 fatty acids. Both are unsaturated fatty acids with the initial double bond between the third and fourth carbons or the sixth and seventh carbons as measured from the methyl end, respectively. These serve multiple purposes in the body such as production of eicosanoids, which affect inflammation and cellular function; production of endogenous cannabinoids, which affect mood and behavior; production of lipoxins and resolvins, which affect inflammation; influence cell signaling and regulation of blood pressure, blood clotting, lipid levels, immune response and gene expression. Seed oils are the primary dietary source of ω-6 fatty acids, while ω-3 fatty acids are found in fish oils and some nut oils. Low levels or unbalanced ratio of them play a key role in a number of human diseases. Therefore, it is important to acknowledge the fatty acids profile in consumed meats which are a major source of fat in the diet, especially of saturated fatty acids (SFA), which have been implicated in diseases associated with modern life, especially in developed countries. The ratio of n-6:n-3 polyunsaturated fatty acids (PUFA) is also a risk factor in cancers and coronary heart disease, especially the formation of blood clots leading to a heart attack [9].

The objective of this study was to examine the effect of breed on fatty acid and amino acids contents of *Pelibuey* and *Polypay x Rambouillet* lamb meat.

MATERIALS AND METHODS

The project was developed in the Biochemistry Laboratory of the Faculty of Agro technological Sciences, Animal Science Laboratory of the Faculty of Husbandry and Ecology, both of the Autonomous University of Chihuahua, with the collaboration of the Cattle Department of the Institute of Biomedical Sciences, from the Autonomous University of Ciudad Juarez.

Sample Obtention of *Longissimus dorsi* Muscle: Twenty-one lambs were used 10 *Pelibuey* (P) and 11 *Polypay x Rambouillet* (PR), distributed in individual pens.

The lambs were weaned sixty days after birth, with a fifteen day adaptation period. The feed consumed was weighed twice a day every twelve hours. The feed supplied increased when the rejection was higher then 5% of the offered portion. The diet contained 65.67% flaked corn, 18.67% alfalfa hay, 23.65% cottonseed meal, 0.5% ammonium sulfate and 0.5% pre-mixture of minerals.

Table 1: Chemical composition of feed.*

Chemical component	
Dry matter (%)	89.66
Moisture (%)	10.34
Protein (%)	15.26
Fat (%)	5.23
Ashes (%)	5.01
Crude Fiber (%)	14.31
Nitrogen-Free Extract (NFE) (%)	60.19
Total Digestible Nutrients (TDN) (%)	83.37
Digestible energy (DE kcal/kg)	3675.59
Metabolizable energy (ME kcal/kg)	3013.67

*Results reported as dry matter.

The chemical composition of the feed is presented in Table 1. When the lambs reached six months of age, they were sacrificed, previously with a twelve hour empty stomach. The sacrifice was by decollation, without previous stunning.

The samples were obtained from the right side of the carcasses after cooled off at 4°C during twenty-four hours, making a cut on the back between the tenth and eleventh thoracic vertebra and the fourth and fifth lumbar vertebra, to obtain the *Longissimus dorsi* muscle, on which the profiles were determined.

***Longissimus dorsi* Sample Preparation:** A portion of approximately 100 g of *Longissimus dorsi* muscle was used, the portion was ground until obtaining a homogenous sample. The meat was stored hermetically in closed and labeled containers and frozen to -10°C until analyzed.

Fatty Acids Profile: The fat extraction was performed according to the Bligh and Dyer method [4] and the methyl esters from fatty acids were prepared using the Morrison and Smith technique [5], taking into account the ISO 5580-1990 and 5509-1978 standards. Fat was extracted using a mixture of chloroform and methanol (1:2), adding the antioxidant 2,6-di-tert-butyl-4-methylphenol and then centrifuged twice. Potassium chloride was added to separate the lipid phase and fatty acids methylated with 5% sulfuric acid in methanol and the samples stored in petroleum ether. The methyl esters of caproic acid (C6:0), capric acid (C10:0), lauric acid (C12:0), myristoleic acid (C14:1), palmitoleic acid (C16:1), oleic acid (C18:1), arachidonic acid (C20:4), docosahexaenoic acid (C22:6) and nervonic acid (C24:1) were also prepared.

The methyl esters were quantified using a gas chromatographer Varian Saturn 3 GC-MS Star 3400 Cx using a capillary column 30m x 0.32mm x 0.25ìm omegawax

320 (Supelco, Inc. Bellefonte, PA, USA). One microliter of sample was injected into the gas chromatographer equipped with a split injector and a flame ionization detector (FID). The oven temperature was 210°C, injector and detector temperatures were 120 and 180°C, respectively. Helium was used as carrier gas at 3 psi. Quantification was done using chromatographic correction factors calculated for each compound in relation to the internal standard solutions of commercial products from Sigma-Aldrich (Germany), carried out in triplicates.

Amino Acid Profile: The sensitive analysis method to determine amino acid profile was used by derivatization with ortho-phtaldialdehido (OPA) submitted by GROM Analytik [6]. The sample was homogenized with a physiological solution of sodium chloride and the norvaline solution was added as an internal standard to precipitate proteins. After centrifuging the samples, the supernatants were subjected to manual derivatization for 90 seconds. Amino acid standards (Essential: ARG arginine, HIS histidine, ILE isoleucine, LEU leucine, LYS lysine, MET methionine, PHE phenylalanine, THR threonine, TRP tryptophan, VAL valine; Non essential: ALA alanine, ASN asparagine, ASP aspartic acid, CYS cysteine, GLN glutamine, GLU glutamic acid, GLY glycine, SER serine, TYR tyrosine) were prepared with a concentration of 2.5 mmol/mL and were derivatized in the same way. The amino acids were separated and quantified, executing triplicates, by a Hewlett Packard HPLC Series 1050, which included a 7952A quaternary pump, a diode array detector Agilent 1100 Series Fluorescence Detector and a 7985A autosampler. A Nucleosil EC 250/4.6 100-5 C18 HD column was used, as eluent A phosphate buffer with tetrahydrofuran and eluent B methanol with acetonitrile and helium as carrier gas.

Statistical Analysis: The statistical package SPSS version 11 was used to compare the data applying a T-Student for Independent samples design (r= 0.99) to establish the differences between the breeds studied against the fatty acids and amino acids contents of *Longissimus dorsi* of the lambs.

RESULTS AND DISCUSSION

According to Table 2 there was absence of essential amino acids threonine and histidine, this last one being present only in one specimen of wool lamb (0.03 mg/g of meat) having no statistical difference (P>0.01) due to the small amount. On the other hand, arginine was only present in half of the wool specimens (0.1965 mg/g of meat) and in almost all of the hair lambs (0.93 mg/g of meat), demonstrating statistical difference (P<0.01). Also the aromatic amino acids, tryptophan was only detected on three wool specimens (0.79 mg/g of meat) being statistically different (P<0.01),

Table 2: Amino acids profile of *Polypay x Rambouillet* and *Pelibuey* lambs *Longissimus dorsi* (mg/g of meat) (μ ± S.D.).

Amino acid	*Polypay x Rambouillet*	*Pelibuey*
Essential		
Arginine	0.19 ± 0.44^{a}	0.93 ± 0.92^{b}
Histidine	0.03 ± 0.10^{a}	ND^{a}
Isoleucine	0.86 ± 0.83^{a}	0.70 ± 0.01^{a}
Leucine	0.66 ± 0.56^{a}	0.45 ± 0.59^{a}
Lysine	214.54 ± 0.30^{a}	211.35 ± 0.57^{a}
Methionine	1.05 ± 0.92^{a}	1.24 ± 0.98^{a}
Phenylalanine	2.70 ± 0.16^{a}	3.85 ± 0.17^{a}
Threonine	ND	ND
Tryptophan	0.79 ± 0.36^{a}	ND^{b}
Valine	3.60 ± 0.61^{a}	5.02 ± 0.84^{a}
Non essential		
Alanine	ND	ND
Asparagine	36.39 ± 0.84^{a}	106.69 ± 0.93^{a}
Aspartic acid	6.04 ± 0.01^{a}	6.77 ± 0.22^{a}
Cysteine	1.03 ± 0.42^{a}	5.08 ± 0.47^{a}
Glutamine	0.36 ± 0.52^{a}	0.03 ± 0.05^{b}
Glutamic acid	2.60 ± 0.95^{a}	1.68 ± 0.19^{a}
Glycine	0.05 ± 0.12^{a}	0.18 ± 0.20^{a}
Serine	0.50 ± 0.63^{a}	1.05 ± 0.13^{a}
Tyrosine	4.08 ± 0.29^{a}	19.18 ± 0.45^{b}

$^{a-b}$ Different letters in the same row indicate statistical difference (P<0.01).
ND not detected

but phenylalanine for PR was 2.70 mg/g of meat and P had very similar results (3.85 mg/g of meat). However, tyrosine was lower for PR (4.08 mg/g of meat) than P (19.18 mg/g of meat). These last results coincide with Gilka *et al.* [7] reported that lambs (breed not specified) had a significant increase in tyrosine (4.45 mg/g of meat). Tyrosine is not normally required directly from the diet because it is synthesized from phenylalanine. But in individuals living with phenylketonuria, who must keep their intake of phenylalanine extremely low to prevent metabolic complications, tyrosine cannot be made and so it becomes essential in the diet [8]. Therefore, P meat would be a good option for people with this condition.

The amino acids containing an atom of sulphur, cysteine and methionine had no statistical significance (P>0.01) for wool nor hair lambs, presenting 1.03 mg/g of meat against 5.08 mg/g of meat and 1.05 mg/g of meat against 1.24 mg/g of meat, respectively. The remaining essential amino acids had no significant difference (P>0.01) among breeds, isoleucine was low for both PR (0.86 mg/g of meat) and for P (0.70 mg/g of meat). Also, leucine reported for PR and P (0.66 mg/g of meat and 0.45 mg/g of meat, respectively). Valine was detected in a higher concentration for P (5.01 mg/g of meat) versus (3.60 mg/g of meat) for PR, not being enough according to the recommended daily intake for lamb fillet [9] of 11.8 mg/g of meat. Lysine presented the highest concentration in both wool and hair lambs, (214.54 mg/g of meat and 211.35 mg/g of meat, respectively) being higher than the reported by Souci *et al*. [10] for muscle lamb (breed not specified) 160 mg/g of meat.

Regarding the non essential amino acids, alanine was not detected in the lambs studied. Aspartic acid was very similar for wool (6.04 mg/g of meat) and hair lambs (6.77 mg/g of meat); asparagine was higher for P (106.69 mg/g of meat) than for PR (36.39 mg/g of meat). The glutamic acid, glycine and serine reported low concentrations in PR (2.60 mg/g of meat, 0.05 mg/g of meat and 0.50 mg/g of meat, respectively) and also for P (1.68 mg/g of meat, 0.18 mg/g of meat and 1.05 mg/g of meat, respectively). None of the previous amino acids exposed statistical difference (P>0.01), only glutamine which was higher for PR (0.36 mg/g of meat) than for P (0.03 mg/g of meat).

Cutinelli *et al*. [11] believed that the total amino acid content was an inverse function of wilderness conditions, when proteins from domestic buffalo skeletal muscle were compared with those from the domestic ox and African buffalo. The amino acid pattern and essential amino acids total content was very similar in the three species. The lysine content was much higher for the domestic buffalo as compared with whole egg proteins and also with the domestic ox. This statement coincides with the high results of lysine obtained for PR and P.

Elgasim and Alkanhal [12] studied camel (*Camelus dromedarius*) amino acids content compared to beef, lamb (breed not specified), goat, chicken and fish; the ratio of essential to non-essential amino acids (ESAA/NEAR) of camel, lamb and goat resulted very similar to beef. In accordance with the previous, the two breeds studied have lower contents of amino acids than any of the above mentioned. Also Dawood and Alkanhal [13] confirmed that najdi-camel meat tended to have a higher percentage of the amino acid proline than literature values for other red meats and lower values for tryptophan, aspartic acid and tyrosine. These results agree with *Polypay x Rambouillet* but not with the high concentration of tyrosine present in *Pelibuey*, excluding proline that was not analyzed in this study.

Hoffman *et al.* [14] analyzing *Longissimus dorsi* (LD) muscle of springbok which presented two main amino acids glutamic and aspartic acid that contributed to 2.47-2.74 and 2.31-2.54 g/100 g of dry matter, respectively. PR and P presented much less amount of glutamic acid and about half the concentration of aspartic acid. On the other hand when studying kudu (*Tragelaphus strepsiceros*) meat, one of Africa's most majestic antelope species, Mostert and Hoffman [15] found that *Longissimus dorsi and lumborum* muscle had higher levels of histidine and valine. However, PR and P did not present histidine, but P had half the amount of valine compared to kudu.

Polidori *et al*. [16] analyzed donkey meat from Martina Franca breed, finding that the percentages of essential amino acids were higher in both muscles studied, compared with the total amino acid content, respectively 52.88% in the *Longissimus* and 51.26% in the *Biceps femoris* exceeding 50% of the total amino acids showed that donkey meat from a health point of view is a good alternative to traditional red meat. Similar results were obtained for donkey meat bresaola (air-dried salted meat, aged about 2-3 months) and cow meat bresaola [17]. Donkey bresaola showed higher content of protein (P<0.01) and essential amino acids (P<0.05) than beef bresaola and no differences were found for sensorial properties. The highest concentrations were obtained for glutamic acid and lysine (5.30 g/100 g of meat), this last one being lower than the results presented for PR and P.

The aging of pork studied by Moya *et al*. [18] produced a general increase in all free amino acid concentrations for the studied quality classes

Table 3: Fatty acids profile of *Polypay x Rambouillet* and *Pelibuey* lambs *Longissimus dorsi* (g/100 g of meat) (μ ± S.D.).

Fatty acid	*Polypay x Rambouillet*	*Pelibuey*
Saturated		
Caproic acid(C6:0)	0.16 ± 0.11^a	0.14 ± 0.06^b
Capric acid (C10:0)	0.0014 ± 0.00^a	0.0007 ± 0.00^b
Lauric acid (C12:0)	0.04 ± 0.02^a	0.05 ± 0.02^a
Monounsaturated		
Myristoleic acid (C14:1)	0.01 ± 0.01^a	0.005 ± 0.00^b
Palmitoleic acid (C16:1)	0.09 ± 0.06^a	0.06 ± 0.02^b
Oleic acid (C18:1)	0.15 ± 0.10^a	0.18 ± 0.08^a
Nervonic acid (C24:1)	0.78 ± 0.67^a	0.59 ± 0.17^a
Polyunsaturated		
Arachidonic acid (C20:4n-6)	0.04 ± 0.02^a	0.05 ± 0.01^b
Docosahexaenoic acid (C22:6n-3)	0.07 ± 0.05^a	0.08 ± 0.02^a
TOTAL	1.39	1.19

[a-b] Different letters in the same row indicate statistical difference (P<0.01).

ND not detected

[red, firm and non-exudative (RFN); pale, soft and exudative (PSE); red, soft and exudative (RSE); dark, firm and dry (DFD)]. The DFD showed higher increases in lysine, alanine and methionine probably due to the activation of neutral aminopeptidases and lower in aspartic acid and serine; PSE had the highest concentration of glutamic acid. Even though, the lambs study did not imply aging effect, comparing amino acids concentrations, pork had higher contents of alanine, methionine, serine and glutamic acid, but PR and P had increased amounts of lysine and aspartic acid.

Sales and Hayes [19] studied the amino acid composition of three different muscles from the legs of seven ostriches. Results indicated that components analyzed remained relatively constant between different muscles. Ostrich meat is characterized by an extremely low intramuscular fat content, but has a similar amino acid profile compared to beef and chicken. Contrasting results with the lambs analyzed, PR and P only presented a higher concentration of lysine and all the rest were minor.

The fatty acid profile can be observed on Table 3, divided in saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA). Referring to the saturated fatty acids, the caproic acid was significantly difference (P<0.01) among breeds, PR contained 0.16 g/100 g of meat and P 0.14 g/100 g of meat. Also capric acid was statistically different (P<0.01) but with less concentration, PR had 0.0014 g/100 g of meat and P had 0.0007 g/100 g of meat. The lauric acid was similar for PR (0.047 g/100 g of meat) and P (0.0566 g/100 g of meat).

The monounsaturated fatty acid with less amount was the myristoleic acid (Ω 5), presenting a significant difference (P<0.01), PR reported (0.011 g/100 g of meat) higher than P (0.005 g/100 g of meat); as well as the palmitoleic acid (Ω 7), PR presented 0.09 g/100 g of meat versus P that had 0.06 g/100 g of meat. The oleic acid and nervonic acid, both Ω 9, were statistically alike (PR 0.15 g/100 g of meat and P 0.18 g/100 g of meat) and PR 0.78 g/100 g of meat and P 0.59 g/100 g of meat), respectively.

Regarding the polyunsaturated fatty acids, the arachidonic acid (Ω 6, ARA) presented significance (P<0.01) among races, PR had 0.04 g/100 g of meat whereas P exposed a higher concentration of 0.05 g/100 g of meat. Instead, the docosahexaenoic acid (Ω 3, DHA) had an increased concentration but alike among breeds (PR 0.07 g/100 g of meat and P 0.08 g/100 g of meat). The recommended daily ingest of ARA is 0.01g and 0.25g of DHA [20]. Therefore, the amount of ARA is high and could be a health issue for individuals with inflammatory diseases like arthritis. On the contrary it is one of the essential fatty acids required by mammals due to its abundance in the brain and is present in similar quantities to DHA. The two account for approximately 20% of its fatty acid content. Like DHA, neurological health is reliant upon sufficient levels of arachidonic acid. Among other things, arachidonic acid helps to maintain hippocampal cell membrane fluidity [21]. It also helps protect the brain from oxidative stress by activating perioxisomal proliferator-activated receptor-y. ARA also activates syntaxin-3 (STX-3), a protein involved in the growth and repair of neurons [22]. And not last but least, plays an important rol in the repair and growth of skeletal muscle tissue.

DHA is a major fatty acid not only in brain as mentioned previously but in sperm and particularly in the retina. Dietary DHA may reduce the risk of heart disease by reducing the level of blood triglycerides in humans because it is antithrombogenic and has antiinflammatory effect. DHA has been found to inhibit growth of human colon carcinoma cells by decreasing cell growth regulators [23]. There is less DHA available in the average diet than formerly, due to cattle being taken off grass a good source of conjugated linoleic acid (CLA) and fed grain before butchering; likewise, there is less in eggs due to intensive farming. Recommendation in the U.S. is that one ingest up to 3 g a day of such oils. In Europe, the recommendation is for up to 2 g. However, omega-3 consumption should be balanced with omega-6 fatty acids, in a ω-6/ω-3 ratio between 1:1 and 4:1 (i.e. no more than four grams of omega-6 for every one of omega-3) [24]. This ratio is quite current for PR:P, although at a lower scale.

When comparing the previous data with Moreiras *et al*. [25] for raw lamb meat (breed not specified), the caproic acid was not analyzed, but the capric acid, lauric acid, palmitoleic acid and oleic acid were lower for the lambs studied. Instead, the myristoleic acid (0.10 g/100 g of meat) and arachidonic acid (0.10 g/100 g of meat) were very similar. The docosahexaenoic acid was lower (0.01 g/100 g of meat) than for the wool and hair lambs analyzed (0.079 g/100 g of meat). The nervonic acid was not detected by [10] but was increased in PR and P.

Wood *et al*. [26] mentioned that the PUFA from commercial loin lamb steaks (breed not specified) was 0.64 g/100 g of meat for arachidonic acid and 0.15 g/100 g of meat for DHA, higher than the results for PR and P.

Applying an alfalfa and oat diet on crossbred *Dorset Horn x Merino* male lambs, Ponnampalam *et al*. [27] obtained the following FA composition on *Longissimus thoracis*, 0.86 g/100 g of meat for oleic acid, a much higher concentration than PR and P, but lower concentrations of ARA and DHA, 0.03 g/100 g of meat and 0.0061 g/100 g of meat, respectively.

Also, *White-faced* ewe lambs were submitted to a beet pulp, oat hay and soybean meal and the FA content of *Longissimus dorsi* was 0.18 g/100 g of meat of palmitoleic acid, 4.07 g/100 g of meat of oleic acid and 0.59 g/100 g of meat of PUFA; all higher values than the ones for PR and P [28].

Additionally, Lee *et al*. [29] studied the FA composition of *Dorset x Suffolk* crossbred lambs *Longissimus dorsi*, supplemented with a diet based on cracked corn, alfalfa pellets, rolled oats and soybean obtaining increased levels of capric acid (0.44 g/100 g of meat), lauric acid (0.53 g/100 g of meat), myristoleic acid (0.15 g/100 g of meat), palmitoleic acid (0.35 g/100 g of meat), oleic acid (40.42 g/100 g of meat) and arachidonic acid (2.44 g/100 g of meat) compared to the lambs studied in this research. These enhanced amounts could be due to the amount of soybean rich in MUFA and PUFA.

Velasco *et al.* [30] analyzed the FA content of unweaned *Talaverana* lambs *Longissimus dorsi* raised at pasture and subsequently fed commercial concentrate. A further decrease in the intramuscular fat content reduced meat quality attributes, especially juiciness and flavor. Variations in fatty acid composition had an important effect on firmness or softness of the fat in meat, especially the subcutaneous and intermuscular (carcass) fats but also the intramuscular (marbling) fat. The FA composition was also higher than PR and P, lauric acid (0.93 g/100 g of meat), palmitoleic acid (3.26 g/100 g of meat), oleic acid (32.03 g/100 g of meat) and arachidonic acid (3.88 g/100 g of meat).

Castro *et al*. [31] also obtained increased values of palmitoleic acid (2.13 g/100 g of meat), oleic acid (38.72 g/100 g of meat) and PUFA (15.92 g/100 g of meat) in *Longissimus dorsi* of male *Ojalada* lambs fed a concentrate containing barley, corn, wheat and soybean meal, when comparing to PR and P.

Similar results were obtained when FA content of *Targhee x Rambouillet* males *Longissimus dorsi* were analyzed, supplemented a diet containing corn, wheat midds, canola meal and dehydrated alfalfa. The composition was also elevated compared to the values presented for PR and P, palmitoleic acid (1.83 g/100 g of meat), oleic acid (29.92 g/100 g of meat) and arachidonic acid (2.07 g/100 g of meat) [32].

Comparable results were acquired for palmitoleic acid (1.52 g/100 g of meat) and oleic acid (31.67 g/100 g of meat), when FA composition of *Mule x Charolais* female lambs *Longissimus* muscle fed barley, oats and soybean meal were studied [33]. Higher values for oleic acid (42.0 g/100 g of meat) and arachidonic acid (3.6 g/100 g of meat) from the *Longissimus* muscle of *Karayaka* young rams fed commercial concentrate and grass hay [34].

Even when analyzing a different muscle as *semimembranosus* in *Santa Inés* male lambs fed grass hay, cracked corn and soybean meal, the contents of caproic acid (0.70 g/100 g of meat), palmitoleic acid (1.37 g/100 g of meat) and oleic acid (39.44 g/100 g of meat) were elevated compared to PR and P, but capric and lauric acid were not detected, due to the nature of the muscle having extension movement [35].

CONCLUSIONS

It is worth mentioning the fact that very few studies on amino acid composition have been developed in the meat area relating breed effect. In the present investigation there was a significant (P<0.01) race effect over arginine, tryptophan, glutamine and tyrosine. Regarding essential amino acids composition, there was absence of threonine and histidine, a low concentration of arginine, isoleucine, leucine, phenylalanine and methionine. Tryptophan only present in *Polypay x Rambouillet* lambs and valine had half the suggested amount. In addition, tryptophan functions as a biochemical precursor for serotonin and niacin and acts as building blocks in protein biosynthesis. While valine is necessary for the proper function of the digestive and nervous system, having influence over the brain uptake of other neurotransmitter precursors (tryptophan, phenylalanine and tryosine).

Lysine exceeded daily intake levels, but this could be a positive factor due to its intervention in the production of elastin and collagen, its major role in calcium absorption and the body's production of hormones, enzymes and antibodies.

According to the fatty acid composition, there was significant statistical results (P<0.01) regarding race over caproic, capric, myristoleic, palmitoleic and arachidonic acids. Among all the revised studies, none reported nervonic acid, which was the fatty acid with the highest concentration for PR and P. This is an essential monounsaturated fatty acid that helps maintain brain health by assisting in the biosynthesis and maintenance of nerve cell myelin and is usually present in some oilseeds. So, analyzing the feed submitted to the lambs is of much concern, since it contains cracked corn and cottonseed meal which could be responsible for its content in the meats studied. From an overall point of view, results indicate a low concentration of saturated, monounsaturated, short and long chain polyunsaturated fat when compared to FDA [36] and EFSA [20] regulations. Therefore, these meats do not represent a health risk and may be a good option for red meat consumption since it is widely consumed in the northern region of Mexico, where mostly beef is preferred.

In general, *Pelibuey* lambs presented a better fatty acid and amino acid profile than *Polypay x Rambouillet*. As expected for wool lambs, having higher values of saturated and monounsatured fatty acids and lower contents of short chain polyunsaturated fat.

It is recommended that further studies be preformed with other lamb races to have a better comparison basis, regarding amino acid profile. Also, to raise the profile of fatty acids in the two species, studying oilseeds composition would be indicated for further incorporation to lambs diets.

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REFERENCES

1. Friedman, M., 1996. Nutritional value of proteins from different food sources. A review. J. Agric. Food Chem., 44(1): 6-29.
2. Yildiz, F., 2009. Advances in Food Biochemistry. CRC Press. pp: 521.
3. Wood, J.D., R.I. Richardson, G.R. Nute, A.V. Fisher, M.M. Campo, E. Kasapidou, P.R. Sheard and M. Enser, 2003. Effects of fatty acids on meat quality: a review. Meat Sci., 66: 21-32.
4. Bligh, E.G. and W.J. Dyer, 1959. A rapid method of total lipid extraction and purification. Canadian J. Biochemistry and Physiol., 37(8): 911-917.
5. Morrison, W.R. and L.M. Smith, 1964. Preparation of fatty acid methyl esters and dimethylacetals from lipids with boron fluoride-methanol. J. Lipid Res., 5: 600-608.
6. GROM Analytik, 2002. Application-Service 004. Sensitive Analysis of Amino Acids by precolumn derivatisation with ortho-Phthaldialdehyde. Denmark.
7. Gilka, J., P. Jelínek, B. Janková, P. Knesel, J. Krej, Ma, Ek and H. Do ecalová. 1989. Amino acid composition of meat, fatty acid, composition of fat and content of some chemical elements in the tissues of male lambs fed monensin or lasalocid. Meat Sci., 25(4): 273-280.
8. Gatellier, P.H., A. Kondjoyan, S. Portanguen, E. Grève, K. Yoon and V. Santé-Lhoutellier, 2009. Determination of aromatic amino acid content in cooked meat by derivative spectrophotometry: Implications for nutritional quality of meat. Food Chemist., 114: 1074-1078.
9. Souci-Fachmann-Kraut, 1991. Tablas de composición de alimentos. Ed. Acribia. España. pp: 100.

10. Souci-Fachmann-Kraut, 2000. Food composition and Nutrition Tables. CRC Press. 6th Edition. pp: 220-224 .
11. Cutinelli-Ambesi, L., V. Bocchini, C. Balestrieri and F. Salvatore, 1975. Amino acid composition of skeletical muscle of domestic buffalo (*Bos bubulus* L.) I. Comparitive study and nutritional value of proteins. Comp. Biochem. Physiol., 51B: 193-195.
12. Elgasim, E.A. and M.A. Alkanhal, 1992. Proximate composition, amino acids and inorganic mineral content of Arabian Camel meat: comparative study. Food Chemis., 45(1): 1-4.
13. Dawood, A.A. and M.A. Alkanhal, 1996. Nutrient composition of Najdi-Camel meat. Meat Sci., 39(1): 71-78.
14. Hoffman, L.C., M. Kroucamp and M. Manley, 2007. Meat quality characteristics of springbok (*Antidorcas marsupialis*) 2: Chemical composition of springbok meat as influenced by age, gender and production region. Meat Sci., 76(4): 762-767.
15. Mostert, R. and L.C. Hoffman, 2007. Effect of gender on the meat quality characteristics of kudu (*Tragelaphus strepsiceros*), an African antelope species. Food Chemis., 104(2): 565-570.
16. Polidori, P., C. Cavallucci, D. Beghelli and S. Vinzencetti, 2009. Physical and chemical characteristics of donkey meat from Martina Franca breed. Meat Sci., 82(4): 469-471.
17. Marino, R., A. Della Malva, G. Gliatta, A. Muscio and A. Sevi, 2009. Quality of donkey bresaola. Ital. J. Anim. Sci., 8(2): 715-171 .
18. Moya, V.J., M. Flores, M.C. Aristoy and F. Toldrá, 2001. Pork meat quality affect peptide and amino acid profiles during aging profiles. Meat Sci., 58: 197-206.
19. Sales, J. and J.P. Hayes, 1996. Proximate, amino acid and mineral composition of ostrich meat. Food Chemis., 56(2): 167-170.
20. European Food Safety Authority. Labelling reference intake values for n-3 and n-6 polyunsaturated fatty acids Scientific Opinion of the Panel on Dietetic Products, Nutrition and Allergies on a request from the Commission related to labelling reference intake values for n-3 and n-6 polyunsaturated fatty acids. (Question No EFSA-Q-2009-00548) Adopted on 30 June 2009.
21. Wang, Z., C. Liang, G.c Li, C. Yu and M. Yin, 2006. Neuroprotective effects of arachidonic acid against oxidative stress on rat hippocampal slices. Chemico-biological interactions, 163(3): 207-217 .
22. Darios, F. and B. Davletov, 2006. Omega-3 and omega-6 fatty acids stimulate cell membrane expansion by acting on syntaxin 3. Nature, 440: 813-817.
23. Schønberg, S.A., A.G. Lundemo, T. Fladvad, K. Holmgren, H. Bremseth, A. Nilsen, O. Gederaas, K.E. Tvedt. K.W. Egeberg and H.E. Krokan, 2006. Closely related colon cancer cell lines display different sensitivity to polyunsaturated fatty acids, accumulate different lipid classes and downregulate sterol regulatory element-binding protein 1. Cancer Lett., 273(12): 2749-2765.
24. Kris-Etherton, P.M., W.S. Harris, L.J. Appel and for the Nutrition Committee, 2002. Fish Consumption, Fish Oil, Omega-3 Fatty Acids and Cardiovascular Disease. Journal of the American Heart Association. 106: 2747-2757.
25. Moreiras, O., A. Carbajal, L. Cabrera and C. Cuadrado, 2004. Tabla de Composición de Alimentos. Ed. Pirámide. 8a Edición. pp: 34-39, 90-119.
26. Wood, J.D., M. Enser, A.V. Fisher, G.R. Nute, R.I. Richardson and P.R. Sheard, 1999. Manipulating meat quality and composition. Proceedings of the Nutrition Society. 58: 363-370.
27. Ponnampalam, E.N. A.J. Sinclair, B.J. Hosking and A.R. Egan, 2002. Effects of dietary lipid type on muscle fatty acid composition, carcass leanness and meat toughness in lambs. J. Anim. Sci., 80: 628-636.
28. Bolte, M.R. B.W. Hess, W.J. Means, G.E. Moss and D.C. Rule, 2002. Feeding lambs high-oleate or high-linoleate safflower seeds differentially influences carcass fatty acid composition. J. Anim. Sci., 80: 609-616.
29. Lee, J.H. J.C. Waller, S.L. Melton, A.M. Saxton and L.O. Pordesimo, 2004. Feeding encapsulated ground full/fat soybeans to increase polyunsaturated fat concentrations and effect on flavor volatiles in fresh lamb. J. Anim. Sci., 82: 2734-2741.
30. Velasco, S., V. Cañeque, S. Lauzurica, C. Pérez and F. Huidobro, 2004. Effect of different feeds on meat quality and fatty acid composition of lambs fattened at pasture. Meat Sci., 66: 457-465.
31. Castro, T., T. Manso, A.R. Mantecón, J. Guirao and V. Jimeno, 2005. Fatty acid composition and carcass characteristics of growing lambs fed diets containing palm oil supplements. Meat Sci., 69: 757-764.
32. Boles, J.A., R.W. Kott, P.G. Hatfield, J.W. Bergman and C.R. Flynn, 2005. Supplemental safflower oil affects the fatty acid profile, including conjugated linoleic acid, of lambs. J. Anim. Sci., 83: 2175-2181.

33. Wynn, R.J., Z.C.T.R. Daniel, C.L. Flux, J. Craigon, A.M. Salter and P.J. Buttery, 2006. Effect of feeding rumen-protected conjugated linoleic acid on carcass characteristics and fatty acid composition of sheep tissues. J. Anim. Sci., 84: 3440-3450.
34. Olfaz, M., N. Ocak, G. Erener, M.A. Cam and A.V. Garipoglu, 2005. Growth, carcass and meat characteristics of Karayaka growing rams fed sugar beet pulp, partially substituting for grass hay as forage. Meat. Sci., 70: 4-14.
35. Madruga, M.S., T.R. De Lucena-Viera, M.G. Gomes-Cunha, J.M. Pereira-Filho, R.C. Ramos do Egypto-Queiroga and W. Hauss de Sousa, 2008. Effect of diets with increasing levels of whole cotton seed on chemical composition and fatty acid profile of Santa Inez (*Santa Inés*) lamb meat. Revista Brasileira de Zootecnia. 37(8): 1496-1502.
36. Food and Drug Administration, Federal Register Advance Notice of Proposed Rulemaking (Food Labeling) 72 FR 62149 November 2, 2007: Revision of Reference Values and Mandatory Nutrients. 72(212): 62149-62175.