

Fatty Acid Content in the Adipose Tissue of Lambs from Hair and Wool Meat Breeds

Piña-Cárdenas, Benjamín A.¹; Cantón-Castillo, Javier J.¹; García-Macías, J.A.²; Torres-Rivera, J.V.³

¹ Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, Campo Experimental La Posta, Paso del Toro, Medellín, Veracruz, México, C. P. 94277.

² Universidad Autónoma de Chihuahua, Facultad de Zootecnia y Ecología de la km. 1 Periférico Francisco R. Almada, Col. Zootecnia, Chihuahua, Chihuahua, México, C. P. 31453.

³ Universidad Autónoma de Chihuahua, Facultad de Ciencias Químicas de la Circuito Universitario S/N, Campus UACH II, Chihuahua, Chihuahua, México, C. P. 31125.

* Correspondence: gcanton.javier@inifap.gob.mx

ABSTRACT

Objective: To evaluate the fatty acid content of the intermuscular adipose tissue (IAT) and perirenal adipose tissue (PAT) of the lambs from hair breeds and their crosses with wool breeds.

Design/Methodology/Approach: Forty-two male lambs were used: 10 Blackbelly (BB), 6 Pelibuey (PB), 6 Katahdin (KT)×BB (KTBB), 10 Charollais (CH)×BB or PB (CHBP), and 10 Suffolk (SF)×BB or PB (SFBP). A linear fixed effects model was used and the following orthogonal contrasts were performed: C1) BB+PB *vs.* KTBB; C2) BB+PB *vs.* CHBP+SFBP; C3) BB *vs.* PB; and C4) CHBP *vs.* SFBP.

Results: The BB and PB lambs recorded the highest saturated fatty acids (SFA), while the CHBP and SFBP had the highest content of monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids in the IAT and PAT ($P<0.05$). Higher proportions of myristic and palmitic acid were found in the IAT and PAT of hair lambs ($P<0.05$). The wool breeds (CHBP+SFBP) had more palmitoleic and oleic acid in the IAT and PAT and linoleic acid in the IAT ($P<0.05$).

Study Limitations /Implications: Lamb meat is believed to be greasy and a higher content of healthy fats is sought for the benefit of consumers.

Findings/Conclusions: Hair lambs had more saturated fatty acids. Meanwhile, the higher content of monounsaturated and polyunsaturated fatty acids in wool lambs is important for the quality and nutritional value of their meat.

Keywords: Hair and wool lambs, adipose tissue, fatty acids.

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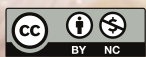
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INTRODUCTION

Meat quality is usually associated with the age of the animal: a higher content of adipose tissue is deposited in the bodies of animals slaughtered at an older age (Della Malva *et al.*, 2016). People believe that sheep meat is greasy and can only be consumed as barbacoa (Rubio *et al.*, 2004; Partida *et al.*, 2017). The fat found in the carcass and the various ways in which meat is prepared (including barbacoa) mainly comes from intermuscular adipose tissue (IAT). The saturated fatty acid content in meats is important for human health

(Castro, 2002; Davis *et al.*, 2022), since most meat consumers seek nutritious products with desirable organoleptic properties, considering, among other aspects, a greater content of monosaturated and polyunsaturated fatty acids, given their positive effect on human health (OMS/FAO, 2003).

Many more studies are required about the fatty acid content of the adipose tissue of lambs from hair and wool breeds, as well as their crosses. Additionally, Zhao *et al.* (2019) and Watkins *et al.* (2021) have highlighted that intermuscular fat is the key factor for the succulence and exceptional flavor of meat. The aim of this study is to determine the fatty acid content of the intermuscular and perirenal adipose tissue of lambs from pure hair breeds and their crosses with wool breeds specialized in meat production.

The hypothesis was that the difference in the fatty acid content of the intermuscular and perirenal adipose tissue between pure hair breeds and their crosses with wool breeds specialized in meat production could influence meat quality.

MATERIALS AND METHODS

The study was carried out in the Faculty of Animal Husbandry and Ecology of the Universidad Autónoma de Chihuahua (28° 38' N and 106° 04' W, at 1,435 m.a.s.l.). The annual average temperature is 17.0 °C and the annual average rainfall reaches 500 mm³ (INEGI, 2016).

Biological material

The experiment included a total of 42 uncastrated male lambs: 10 Blackbelly (BB), 6 Pelibuey (PB), 6 Katahdin (KT)×BB (KTBB), 10 Charollais (CH)×BB ó PB (CHBP), and 10 Suffolk (SF)×BB ó PB (SFBP). They had a mean live weight ± standard deviation (SD) of 20.47±2.52 kg. The animals were housed in individual pens, where they were provided with a commercial diet (Table 1), consisting of 13.0% crude protein (CP) and 2.43 megacalories of metabolizable energy per kilogram of dry matter (Mcal ME/kg DM).

Before the start of the test, the lambs were dewormed with an Ivermectine intake. They were given a 14-day period to adapt to the diet and the pens. They were weighted after a 16-hour fast every 14 days, from the start to the end of the 98-day experiment. At the end of the experiment, all the animals were slaughtered, after a 16-hour fast, according to the Official Mexican Standard for the Slaughter and Cutting of Animals (NOM-033-SAG/ZOO-2014). The head was cut at the occipito-atloid articulation, while the skin, the hooves, parts of the thoracic cavity (organs and glands), and the content of the abdominal and pelvic cavities (gastrointestinal content) were removed from the carcass. The empty carcass was refrigerated at 4 °C for 24 hours. Subsequently, the carcasses were cut in half along the spinal column. The left half was dissected and divided into muscles, bones, and fat. Fat samples were taken from the leg muscles were taken from each animal (intramuscular, IAT), as well from the kidneys (perirenal, PAT). Each sample weighted ≈30 g. The samples were vacuum-packed and frozen at -20 °C until they were subjected to a chemical analysis. Prior to the analysis, they were defrosted for 24 h at 4 °C. The fatty acid (FA) contented was measured using a gas chromatography, following method 996.06 of the AOAC (2012).

Table 1. Ingredients and chemical composition of the diet.

Ingredients	DM (%)
Rolled corn	57.60
Alfalfa hay	20.80
Cottonseed meal	11.80
Corn gluten meal	5.00
Cane molasses	3.60
Common salt (NaCl)	0.40
Mineral premix (Microfos MNA)	0.40
Calcium carbonate	0.40
Total	100.00
Chemical composition	
Dry matter (%)	86.70
Crude protein (%)	13.05
Calcium (%)	0.52
Phosphorus (%)	0.31
ME (Mcal/kg DM) ^a	2.43

Estimated based on (NRC, 1985).

Data analysis

The results were analyzed with a generalized linear model (GLM) with fixed effects, which included the effect of the paternal genetic group. Means were compared through orthogonal contrasts, using SAS procedures (SAS Inst. Inc., 2003): C1) BB+PB *vs.* KTBB; C2) BB+PB *vs.* CHBP+SFBP; C3) BB *vs.* PB; and C4) CHBP *vs.* SFBP.

RESULTS AND DISCUSSION

Table 2 shows the effect of the genetic group on the fatty acid content of the IAT, while Table 3 shows its effect on PAT. A significant effect ($P < 0.05$) was recorded regarding the content of saturated FA (SFA) had on the IAT and PAT, when lambs from hair and wool (C2) breeds are contrasted, as well as when PB+BB *vs.* KTBB (C1) was compared with BB *vs.* PB (C3). BB and PB lambs recorded the highest SFA in IAT and PAT ($P < 0.05$), which was key for their group; however, CHBP and SFBP specimens had a higher MUFA concentration ($P < 0.05$) in IAT and PAT than BB and PB (C2) specimens. No significant differences ($P > 0.05$) were recorded in SFA y MUFA percentages of the IAT and PAT between wool sheep groups (C4). Tavares *et al.* (2018) reported similar SFA and MUFA contents in the perirenal fat of Santa Inés lambs, while Karaca *et al.* (2016) reported similar results in the subcutaneous and tail adipose tissue of wool lambs. The IAT of wool crosses had a higher concentration ($P < 0.05$) of polyunsaturated FA (PUFA) than the IAT of hair races (C2); no differences were found in the PAT of the other animal groups evaluated ($P > 0.05$). Maleki *et al.* (2015) reported similar results in the subcutaneous fat of wool lambs. For their part, Karaca *et al.* (2016) reported a higher PUFA proportion in the subcutaneous and tail fat of wool lambs, possibly as a consequence of the various types of fatty deposits used in both studies.

Table 2. Effect of the genetic group on the fatty acid content of the intermuscular fat of lambs.

Fatty acids profile (% of total)	Genetic group					Orthogonal contrasts			
	BB	PB	KTBB	CHBP	SFBP	C1	C2	C3	C4
Saturated fatty acids	45.0±1.15	51.4±1.37	43.8±1.62	44.5±1.15	44.5±1.15	*	*	*	NS
Monounsaturated fatty acids	51.7±1.08	44.6±1.29	52.0±1.52	51.2±1.08	51.4±1.08	*	*	*	NS
Polyunsaturated fatty acids	3.3±0.27	4.0±0.32	4.2±0.38	4.3±0.27	4.1±0.27	NS	*	NS	NS
Myristic acid (C14:00)	4.1±0.30	5.3±0.36	4.1±0.42	3.2±0.30	3.6±0.30	NS	*	*	NS
Palmitic acid (C16:00)	27.3±0.74	28.2±0.88	27.5±1.05	24.7±0.74	25.3±0.74	NS	*	NS	NS
Stearic acid (C18:00)	13.6±0.80	17.9±0.96	12.2±1.13	16.7±0.80	15.6±0.80	*	NS	*	NS
Palmitoleic acid (C16:1 n-9C)	1.1±0.16	1.7±0.19	2.2±0.22	1.9±0.16	1.8±0.16	*	*	*	NS
Oleic acid (C18:1 n-9C)	50.58±1.12	43.0±1.34	49.8±1.58	49.3±1.12	49.6±1.12	NS	*	*	NS
Linoleic acid (C18:2 n-6C)	3.06±0.25	3.8±0.30	3.9±0.36	3.9±0.25	4.0±0.25	NS	*	NS	NS
Eicosatrienoic acid (C20:3 n-9C)	0.19±0.05	0.2±0.06	0.3±0.07	0.3±0.05	0.2±0.05	NS	NS	NS	*

Note: *= $P < 0.05$; NS=Not significant; C1=BB+PB vs. KTBB; C2=BB+PB vs. CHBP+SFBP; C3=BB vs. PB; C4=CHBP vs. SFBP.

Table 3. Effect of genetic group on fatty acid composition in perirenal fat of lambs.

Fatty acids profile (% of total)	Genetic group					Orthogonal contrasts			
	BB	PB	KTBB	CHBP	SFBP	C1	C2	C3	C4
Saturated fatty acids	55.7±0.81	58.2±0.97	52.1±1.15	53.7±0.81	52.7±0.81	*	*	*	NS
Monounsaturated fatty acids	39.8±0.73	37.7±0.88	43.4±1.04	41.9±0.73	42.6±0.73	*	*	NS	NS
Polyunsaturated fatty acids	4.5±0.24	4.0±0.29	4.5±0.35	4.3±0.24	4.7±0.24	NS	NS	NS	NS
Myristic acid (C14:00)	3.5±0.2	3.8±0.3	2.7±0.3	2.7±0.2	2.4±0.2	*	*	NS	NS
Palmitic acid (C16:00)	25.8±0.6	26.0±0.8	23.9±0.8	23.8±0.6	22.9±0.6	*	*	NS	NS
Stearic acid (C18:00)	13.6±0.80	17.9±0.96	12.2±1.13	16.7±0.80	15.6±0.80	*	NS	*	NS
Palmitoleic acid (C16:1 n-9C)	0.5±0.1	0.6±0.2	1.0±0.2	0.9±0.1	0.9±0.1	NS	*	NS	NS
Oleic acid (C18:1 n-9C)	39.2±0.7	37.1±0.9	42.4±1.0	41.0±0.7	41.9±0.7	*	*	NS	NS
Linoleic acid (C18:2 n-6C)	4.4±0.2	4.0±0.3	4.4±0.3	4.2±0.2	4.5±0.2	NS	NS	NS	NS
Eicosatrienoic acid (C20:3 n-9C)	0.1±0.03	0.1±0.04	0.2±0.04	0.2±0.03	0.2±0.03	NS	*	NS	NS

Note: *= $P < 0.05$; NS=Not significant; C1=BB+PB vs. KTBB; C2=BB+PB vs. CHBP+SFBP; C3=BB vs. PB; C4=CHBP vs. SFBP.

The IAT and PAT of hair lambs had a higher proportion ($P < 0.05$) of myristic (40%) and palmitic (11%) acid than the IAT and PAT of wool lambs (C2). The IAT of PB and BB lambs had a higher content of stearic acid (29%) the PAT of KTBB ($P < 0.05$). Meanwhile, the PAT of the same breeds had a higher content of myristic (35%) and palmitic (8%) acid than the PAT of KTBB ($P < 0.05$). These findings match the results of Tavares *et al.* (2018) and Yagoubi *et al.* (2020), who reported a greater amount of palmitic and stearic acid in the visceral and perirenal fat of hair sheep. The higher concentration of these fatty acids in hair sheep could be associated with the gene expression found in the various deposits, which depend on the breed of the specimens (Yue *et al.*, 2016; Cui *et al.*, 2022). In contrast, the IAT and PAT of lambs from wool breeds (CHBP+SFBP) had more ($P < 0.05$) palmitoleic (35 to 63%) and oleic (6 a 9%) acid; likewise, their IAT had more linoleic acid (8%) than the IAT of hair sheep (BB+PB) (C2). The IAT ($P < 0.05$) of BB lambs had the highest oleic acid (18%) concentration among hair breeds (C1). Karaca *et al.* (2016) reported a lower oleic acid and a similar linoleic acid content, in both the subcutaneous and tail fat of wool lambs provided with a concentrate-based feed. However, Meale *et al.* (2015) reported a higher concentration of linoleic acid in the subcutaneous and renal adipose tissue of wool lambs, perhaps because these authors used different plant oils in the diet of the animals. The PAT of wool lambs recorded double the eicosatreinoic acid content ($P < 0.05$) than the PAT of PB+BB (C2). Comparing wool breeds (C4), CHBP had 50% more eicosatreinoic acid than SFBP ($P < 0.05$). The highest concentration of acid in wool breeds is caused by their higher amount of oleic acid, which is desaturated to produce eicosatreinoic acid (Sakuradani *et al.*, 2002). No significative differences were reported in the oleic acid proportions for the following contrasts: C1 and C4 for IAT and C3 and C4 for PAT ($P > 0.05$). Neither were they found in the linoleic acid content of C1, C3, and C4 for IAT, nor for any PAT group. Finally, no significative differences were found in the proportion of eicosatreinoic acid for the following contrasts: C1, C2, and C3 for IAT and C1, C3, and C4 for PAT ($P > 0.05$). Song *et al.* (2017) report lower concentrations of eicosatreinoic acid in the kidney and subcutaneous fat of crossed Dorper lambs fed with concentrates.

These findings have major implications for the meat industry and its consumers. On the one hand, the higher concentration of saturated fatty acids in hair lambs could be associated with sensory properties that consumers find valuable, such as succulence and flavor. On the other hand, the higher proportion of monosaturated and polyunsaturated fatty acids in wool lambs can provide a healthier nutritional profile. These differences help to diversity meat products, satisfying both the taste preferences of the consumers and their nutritional requirements.

CONCLUSIONS

Hair lambs have higher levels of saturated fatty acids, while wool lambs have more monosaturated and polyunsaturated fatty acids. These differences influence the sensory and nutritional quality of meat, highlighting the importance of the characteristics of the breeds regarding consumer preferences and health requirements.

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