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Effects of supplementation with tropical dry forest tree foliage on meat quality and fatty acid composition in Colombian creole lambs (*ovis aries*)*

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Abstract

In tropical dry forest conditions, small ruminant production is an alternative for small farmers. Even so, the quality of the forages does not meet the nutritional requirements of the animals. However, the high biodiversity of trees that exist in the region offers a supplementation alternative especially during the dry season. The objective of this research work was to evaluate the quality and the profile effect of fatty acids in Colombian creole lamb meat supplemented with tree species from the tropical dry forest. A total of 35 lambs were used which were randomly distributed in 5 treatments as follows: T1: *Botriochloa pertusa*; T2: *Botriochloa pertusa* + 300 g/day of *Leucaena leucocephala;* T3: *Botriochloa pertusa* + 300 g/day of *Gliricidia sepium;* T4: *Botriochloa pertusa* + 300 g/day of *Guazuma ulmifolia* and T5 (BpSs): *Botriochloa pertusa* + 300 g/day of *Senna spectabilis*. The experimental units were brought to a final slaughter weight of ±32 kg and the pH, color, and fatty acid composition of the carcasses were evaluated at 24 hours. The meat quality parameters did not present significant differences (P>0.05) in the different supplements and obtained acceptable parameters for their consumption. It was evidenced that the proportions of saturated fatty acids (C 16: 0, C 18: 0, total SFA) in lambs supplemented with *Senna spectabilis* and *Gliricidia sepium* were lower (P<0.05). It is concluded that under the conditions of the study the supplementations with Senna spectabilis and Gliricidia sepium can induce a favorable change in the fatty acid content of lamb meat.

Key words: *Gliricidia sepium; Guazuma ulmifolia; Leucaena leucocephala; Senna spectabilis; Silvopastoral systems.*

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Efectos de la suplementación con follaje de árboles del bosque seco tropical sobre la calidad de la carne y la composición de ácidos grasos en corderos criollos colombianos (*ovis aries*)

Resumen

En condiciones de bosque seco tropical, la producción de pequeños rumiantes es una alternativa para los pequeños agricultores. No obstante, la calidad de los forrajes no atiende a los requerimientos nutricionales de los animales. Sin embargo, la alta biodiversidad de árboles que existe en la región ofrece una alternativa de suplementación especialmente en la época seca. El objetivo de este trabajo de investigación fue evaluar la calidad y el perfil de ácidos grasos en carnes de corderos criollos colombianos suplementados con especies arbóreas del bosque seco tropical. Se utilizaron 35 corderos los cuales fueron distribuidos aleatoriamente en 5 tratamientos: T1 (control) = pastoreo en *Botriochloa pertusa*; T2= pastoreo en *Botriochloa pertusa* + 300 gr/día de suplemento a base de *Leucaena leucocephala; T3*= pastoreo en *Botriochloa pertusa + 300 gr/día* de *Gliricidia sepium; T4*= pastoreo en *Botriochloa pertusa* + 300 gr/día de *Guazuma ulmifolia* y *T5*= pastoreo en *Botriochloa pertusa + 300 gr/día* de *Senna spectabilis*. Las unidades experimentales fueron llevadas a un peso final de sacrificio de ± 32 kg y se evaluó el pH a las 24 horas, el color y el perfil lipídico de las canales. Los parámetros de calidad de la carne no presentaron diferencias estadísticas significativas ($P>0.05$) en las diferentes suplementaciones y obtuvieron parámetros aceptables para su consumo. Se evidencio que las proporciones de ácidos grasos saturados (C 16:0, C 18:0, total de SFA) en los corderos suplementados con *Senna spectabilis* y *Gliricidia sepium* fueron menores ($P<0.05$). Se concluye que bajo las condiciones del estudio las suplementaciones con *Senna spectabilis* y *Gliricidia sepium* pueden inducir un cambio favorable en el contenido de ácidos grasos de la carne de corderos.

Palabras claves: *Gliricidia sepium*; *Guazuma ulmifolia*; *Leucaena leucocephala*; *Senna spectabilis*; Sistemas silvopastoriles.

Introduction

Red meat consumption has been associated with cardiovascular diseases in humans, thus, representing a serious concern for public health (Lippi et al., 2015). Obesity increase is caused by the consumption of high-carbohydrate and high-fat diets characterized by their high energy content, which leads to an excess accumulation of fat (Binnie et al., 2014). Red meats present a lipid profile with higher levels of Saturated Fatty Acids (SFA) compared with fish and chicken. Moreover, the ruminant meat levels of monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA) are lowest because of the biological process of biohydrogenation made it in the rumen (Kouba & Mourot, 2011). The biohydrogenation process only allows the passage of 2% to the MUFA that are consumed (Buccioni et al., 2012). Therefore, most of the fatty acids deposited in muscle tissue are SFA. In the last few years, many researchers have looked for ways to reduce the levels of SFA in ruminants meat.

One of the most studied techniques is the supplementation with fats and oils coated with proteins, calcium soaps, and amide formations to protect MUFA and PUFA biohydrogenation and increasing their absorption in the small intestine (Cabiddu et al., 2005). However, this is an expensive technology for small-scale producers the return of investment is not readily seen. Because of that, in developing countries, there is a potential to explore the effect of tree leaves to modify the lipid profile of ruminants meat (Gadeyne et al., 2015; Sun et al., 2015). Also, this type of feeding has economic advantages because it can increase productivity and generates greater added value Besides, the PUFA concentration is higher in ruminants grass-fed than grain-fed (Cividini et al., 2014). Likewise, the maturity stages of the forage sources have a great impact on the meat fatty acid levels. In tropical farms, there is a great diversity of plants using for feeding that affect fat metabolism and its deposition in the muscles (Glasser et al., 2013).

Small ruminants farming in grazing systems is an economic activity with a high level of importance for farmers in the tropical dry forest (Adams & Ohene, 2014). However, these small productions do not have access to technology and the investment is limited, thus, affecting the productivity parameters and income (Malik et al., 2015). On the other hand, there are some unexplored benefits of these productions, such as the production of organic meats and the use of fruits and tree foliage t can improve the productivity and the quality of meat products (Caroprese et al., 2015).

Thus, this study was conducted to evaluate the effect of dietary supplementation with foliage from four tropical dry forest trees on meat quality and fatty acid composition in Colombian creole grazing lambs.

Materials and methods

Local, animal management, and chemical composition

This experiment was conducted at the experimental center "El Recreo" (326 AMSL, 32°C y 750 mm per year) of the Universidad del Tolima located at74º04`39``W and 4º35`46``N in the department ofTolima (Colombia). We allocated 35 Colombian creole lambs (23.4 ± 0.6 kg initial body weight, 175 ± 15 days of age). They were distributed in a completely randomized experimental design with 5 treatments and 7 experimental units by treatment. The treatments wereT1 (control): grazing in *Botriochloa pertusa*; T2: grazing in *B. pertusa* + 300 g/day concentrate with *Leucaena leucocephala*; T3: grazing in *B. pertusa* + 300 g/day concentrate with *Gliricidia sepium*; T4: grazing in *B. pertusa* + 300 g/day concentrate with *Guazuma ulmifolia* and T5: grazing in *B. pertusa* + 300 g/day concentrate with *Senna spectabilis*. The concentrate for T2, T3, and T4 treatments was made with the foliage of the trees, meanwhile, for the T5 treatments we used the tree fruit, and all of them contained a premix and rice flour for all (Table 1).

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Table 1. Ingredients and chemical composition of diets administered to Colombian creole lambs

Nutrients	Rice flour	*B. pertusa*	*L. leucocephala*	*G. sepium*	*G. ulmifolia*	*S. spectabilis*
Dry matter	91.1	33.0	21.3	28.0	38.2	74.9
Crude protein	11.3	6.8	27.3	22.3	10.4	9.8
NDF	27.4	67.2	35.4	35.2	58.5	55.1
ADF	14.3	52.3	34.8	33.7	53.9	39.4
Ash	10.7	12.0	5.7	8.3	3.1	9.9
Ether extract	3.3	1.3	3.7	3.4	2.7	1.3

NDF: Neutral detergent fiber; ADF: Acid detergent fiber.

Source: Author

The lambs were fed with the diets until obtain an average live weight of 32 (±1) kg for an experimental period of 120 d. The lambs were in grazing between the 09:00 - 17:00 with *ad libitum* offer of *B. pertusa*, water, and salt. The concentrate was supplied twice a day in each group in the feedlot (08:00 and 17:00).

Instrumental meat quality

The lambs were slaughtered at 32 (±1) kg, following the normativity of animal and welfare protection (OIE, 2013). The *Longissimus dorsi* (LD) was removed from both sides of the carcass and was transported under refrigeration at 4°C for further analyses at the meat quality laboratory of the University of Tolima. To evaluate meat color, a Chroma Meters CR-400 portable colorimeter was used. Results were expressed (lightness, L^*; redness, a^*; yellowness, b^*) as the average of three measurements. After 24 h post-mortem, a Hanna Instruments HI 99163N was used for pH evaluation.

Were extracted 30 g of LD which were stored frozen at - 80°C (Wood et al., 2008) for the fatty analysis. Once the 35 samples were obtained, they were lyophilized and sent to the Toxicology Laboratory of the Universidad Nacional de Colombia for fatty acid analyzed profile according to Folch et al. (1957) and Association of Official Analytical Chemists (2007).

Statistical analysis

A completely randomized design was performed; the data was analyzed using the SAS 9.2 MIXED procedure. Shapiro Wilk test was used to evaluate normality. An ANOVA analysis of variance and a Tukey mean comparison test were performed, with a 95% level of significance. The model used in the experiment was as follows:

$$Yijk = U + Ti + Bj + Eijk$$

Where: Yijk: Dependent variable; U: Medium, Bj: Fixed effect of the Block, Ti: Fixed effect of the treatment (i = 0, 1, 2), Eijk: Residual error.

Results and discussion

Instrumental Meat quality

No significant differences were observed among groups regarding meat quality parameters (p>0.05). Color and pH values found in this study were similar to previous reports (D'Alessandro et al., 2013; Jiang et al., 2015) (Table 2). Thus, it is very important the pH decline in the first 24 hours post-mortem as it permits the conversion of muscle to meat. The pH should reach a value of approximately 5.5 in the first 24 hours because it will influence the amount of water retained by the muscle and its aging (Huff-Lonergan & Lonergan, 2005). Moreover, the pH decrease pH to 5.6 enables proteolysis and improves the meat tenderness to the meat (Hopkins et al., 2011). The meats in this study obtained an acceptable pH value (5.7±0.2), thus, edible for human consumption. On the other hand, there is a minimum-effect of the diet on meat pH values (Ekiz et al., 2009; Luciano et al., 2012).

Table 2. Effect of dietary supplementation with tropical dry forest trees foliage on carcass characteristics and meat quality in Colombian creole lambs

Item	**Treatments**					**p-Value**
	T1	**T2**	**T3**	**T4**	**T5**	
Live weitgh (kg)	30.71	30.91	31.02	31.79	30.65	0.11
Carcass weight (kg)	12.08	12.33	12.71	12.45	12.55	0.31
Carcass yield (%)	39.33	39.89	40.98	39.16	40.95	0.16
pH24h	5.72	5.81	5.76	5.72	5.79	0.38
Lightness, L*	31.68	33.09	32.66	31.93	32.43	0.89
Redness,, a*	14.84	16.38	16.02	15.22	15.71	0.34
Yellowness, b*	3.55	4.54	4.46	3.77	3.88	0.48

T1: grazing in *B. pertusa;* T2: grazing in *B. pertusa* + 300 g/day concentrate with *L. leucocephala;* T3: grazing in *B. pertusa* + 300 g/day concentrate with *G. sepium;* T4: grazing in *B. pertusa* + 300 g/day concentrate with *G. ulmifolia;* T5: grazing in *B. pertusa* + 300 g/day concentrate with *S. spectabilis.*

Source: Author

Meat color is an important parameter for evaluation of meat aging being both groups of myoglobin (oxi/met) determine this characteristic. In many studies, when the coordinate *a* is superior to 18, it is a signal that the oxidation of iron is high and the meat quality is low (Wood et al., 2004). On the other hand, when the oxygen present has not oxidized the color of meat becomes bright red and the coordinate *b* will be possible to found above 9, indicating bacterial colonization and meat decomposition (Ponnampalam et al., 2012). Regarding coordinate *L,* this one is closely related whit the coordinates *a* and *b*. Only to distinguish which one offers the greatest influence we may have to determine the type of myoglobin who predominates in the meat (Leygonie et al., 2012).

Fatty acid composition

The fatty acid profile in this study was similar to the previous reports (Scerra et al., 2011; Vasta et al., 2012; Gómez et al., 2014). The content of saturated fatty acids (SFA) in the meat was lower in T3 and T5 (Table 3). However, the MUFA and PUFA levels do not show differences among the treatments ($p>0.05$).

Table 3. Fatty acid composition (g/100 g of identified fatty acid) in Longissimus dorsis of Colombian creole lambs with dietary supplementation with tropical dry forest trees foliage

Fatty Acid	Treatment					p Values
	T1	T2	T3	T4	T5	
C14:0	2.32	1.93	1.67	2.73	2.07	0.079
C15:0	0.73	2.57	0.69	0.77	3.17	0.596
C16:0	28.13[a]	28.63[ab]	28.43[ab]	30.69[b]	27.00[a]	0.005
C16:1	0.47[a]	2.02[a]	3.81[b]	1.01[a]	1.48[a]	0.006
C17:0	1.57	2.73	2.21	1.33	1.43	0.368
C18:0	28.87[b]	20.53[a]	22.73[ab]	26.69[ab]	20.58[a]	0.023
C18:1n	33.63	30.53	31.09	33.17	32.77	0.772
C18:2n	2.56	3.77	3.77	2.93	4.07	0.576
C18:3n-6	0.05	1.22	0.71	0.53	0.23	0.445
C18:3n-3	0.27	0.23	0.53	0.27	0.47	0.887
PUFA	2.83	7.23	8.02	3.73	7.77	0.567
MUFA	36.11	32.53	34.92	34.17	34.27	0.928
SFA	61.62[bc]	56.39[ab]	55.53[a]	62.23[c]	54.05[a]	0.002

T1: grazing in *B. pertusa;* T2: grazing in *B. pertusa* + 300 g/day concentrate with *L. leucocephala;* T3: grazing in *B. pertusa* + 300 g/day concentrate with *G. sepium;* T4: grazing in *B. pertusa* + 300 g/day concentrate with *G. ulmifolia;* T5: grazing in *B. pertusa* + 300 g/day concentrate with *S. spectabilis.* Different letters set a statistical difference by Tukey test ($p<0.05$).

Source: Author

Changes in the fatty acid composition of meat depend principally on factors associated with the diet. Animals fed with high-forage diets tend to have a different fatty acid profile compared with animals fed with concentrate (Bauman et al., 2000).

However, the nutritional composition of the diets can have a huge impact on metabolism and the lipid profile of the meat. In some cases, the increase of the percentage ADF in the forage is directly related to the increment of contents C18:0 on meat (Teixeira et al., 2015). Also, the variation in C16:0 has been linked to the racial effect rather than the system feeding (Turner et al., 2014; Hajji et al., 2016). The passage rate of forage in the rumen is related to the contents of SFA in meat, when the degradation is slow the SFA levels tend to be higher (Whitney & Smith, 2015). High contents of fiber can induce high contents of SFA in meat.

Conclusion

Supplementation with *S. spectabilis* and *G. sepium* have the potential to decrease the content of saturated fatty acids, especially palmitic acid. MUFA and PUFA levels were not affected by the dietary supplements We suggest that futures studies should include a major proportion of supplements for evidence notarial changes, especially in carcass parameters. We concluded that the supplementation with tropical dry forest trees foliage trees of tropical dry forest under our conditions do not affect the Instrumental meat quality and contribute to decreasing the saturated fatty acids content.

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