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Correlation between lipid, cholesterol and fatty acid contents in the shoulder of castrated and non-castrated Santa Inês lambs[1]

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ABSTRACT - The objective of this study was to establish a correlation between the content of total lipids, cholesterol and fatty acid profile of the edible portion of the shoulders of 12 castrated and 12 non-castrated Santa Ines lambs, slaughtered at different ages (84, 168, 210, 252 days). Shoulders and the edible portion (muscle and fat) were weighed and stored at -5 °C. Castrated and uncastrated lambs increased their body weight and half carcass weight, respectively. The shoulder weight increased in the carcasses of uncastrated animals. The edible portion of the shoulders of castrated lamb has greater amount of total lipids (16.09 g/100 g). The cholesterol content was influenced by castration, reducing with age. Santa Ines castrated lambs, under semi-extensive conditions, presented larger amounts of C18:1 T11 and CLA in the edible portion of the shoulder. Castration causes no significant correlation between total lipids, cholesterol and total saturated and unsaturated fatty acids of the edible portion of Santa Ines shoulder lambs from 84 to 252 days of age.

Key Words: carcass, cut, composition, sheep

Introduction

The lamb is characterized by high concentration of saturated fatty acids and low polyunsaturated:saturated acid ratio (Cooper et al., 2004). However, different amounts of fatty acids can be found in different carcass cuts, because the fat distribution is uneven. Rodrigues et al. (2008) identified that the fatty acids in higher proportions in meat (*longissimus dorsi*) of Santa Ines lambs were C18: 1, C16: 0 and C18: 0. The C18: 1 fatty acid was also found in greater quantity in the study conducted by Madruga et al. (2008) and Costa et al. (2009). However, these authors analyzed the muscle of the lamb and not the edible portion of carcass cut.

Santos-Cruz & Pérez (2000) and Santos-Cruz et al. (2008a) claim that the poor presentation and excess fat in the carcasses and cuts is one factor that affects the consumption of sheep meat. Thus, the lipid composition of the cuts is relevant information and may stimulate the marketing of this meat.

Lipids play an important role in the diet, because of their energy value (8.5 kcal/g), essential fatty acids, fat-soluble vitamins and phospholipids (Pardi et al., 1993). However, these total lipids in meat and carcass are influenced by age and weight at slaughter (Furusho-Garcia et al., 2006; Jardim et al., 2007; Santos-Cruz et al., 2008a, 2008b), as well as the sexual condition of the animal.

According to Silva Sobrinho et al. (2005), castration is an unnecessary management practice in the production system of lambs for slaughter, once the stress has an adverse effect on growth rate. Ribeiro et al. (2003) concluded that castration does not affect performance of animals for finishing at 30 kg of live weight, i.e., there is no need for castration of lambs for slaughter.

Although the demand for sheep meat is high, supply is low and unstable, so it is a limiting factor in marketing of lamb, in addition to the lack of concise information about quality characteristics and physicochemical profile. The scientific papers related to lipid composition of the edible portion are few and sometimes contradictory and difficult to compare, since for most of them the determination is performed in only one muscle. Moreover, most data come from animal studies of temperate climate. There is a need to also work with breeds adapted to the ecological conditions of the Brazilian Northeast.

Considering the marketing potential of lambs in both domestic and international markets, the objective of this study was to correlate the total lipid content, cholesterol

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and fatty acids in the edible portion of the shoulder of castrated and uncastrated Santa Ines lamb at different ages (84, 168, 210, 252 days) subjected to semi-intensive system.

Material and Methods

The experiment was developed at Unidade Experimental de Caprinos e Ovinos (UECO) of Universidade Estadual do Sudoeste da Bahia (UESB), Itapetinga, Bahia campus, Southwest Bahia, Brazil; and at the Experimental Station of Empresa Baiana de Desenvolvimento Agrícola (EBDA) in Jequié, Bahia. Twelve castrated and 12 non-castrated lambs were slaughtered at 4 different ages (84, 168, 210, 252 days) – 3 lambs per age of slaughter castrated at one month of age and weaned at 84 days. Lambs were subjected to the semi-intensive production system, with grazing during the day in areas planted with *Green panic* grass, *Panicum maximum* and *Brachiaria decumbens* and supplemented with mineral salt and 22% crude protein concentrate, supplied at the amount of 2.2% in relation to body weight and divided into two daily meals. During the cold period, from June to October, when there was a decrease in pasture quality, supplemental mineral mixture (protein energized mineral supplement) was offered.

Slaughter operations were performed according to the methods recommended by the Ministry of Agriculture (BRASIL, 2008) when the lambs reached pre-established ages, after a fasting of solid feed for 16 hours, and weighted to obtain the live weight (LW) at slaughter.

At slaughter, under sanitary evaluation of a veterinarian, the animals were stunned by concussion, then bled through the section of the carotid arteries and jugular vein, with blood collection and weighing. Afterwards, animals were eviscerated and the carcass was obtained, then cleaned, weighed and taken to a cold room at 2±0.5 °C for a period of 24 hours. After this period, shoulders were obtained from the left half part through the system of cuts adopted by Santos-Cruz et al., (2001a,b); therefore, there were 3 cuts per lamb per age, considering the shoulders a choice cut. Shoulders were weighed and stored in a freezer at - 5°C for further dissection and removal of the edible portion (muscle and fat) to determine the amount of lipids, cholesterol and fatty acid profile.

The shoulder was the chosen cut due to the amount of muscle and adipose tissue and the chance of it having fatty acids that promote rancidity in the flesh of lambs; the shoulder is also considered a prime and also choice cut, depending on the cut system adopted. In addition to the shoulder, other cuts may interfere with the characteristics of sheep meat, since they represent distinct anatomical regions that have different physical and chemical composition due to different rates of synthesis and deposition of nutrients to tissues (Santos-Cruz et al., 2001b; 2008b).

The shoulder cuts of castrated and non-castrated lambs, at different ages were removed from the freezer 12 hours before dissection, thawed at room temperature and weighed individually once more. With dissection, i.e., separation of the tissue components (bone, muscle, fat and other tissues) of each cut with the aid of a scalpel and knife, the edible portion (muscle and fat) could be used for chemical analysis. The subcutaneous, intramuscular and intermuscular fats were ground together, so they were part of the edible portion, as well as the muscle that was represented by all the muscles that make up the shoulder.

The edible portion of the shoulders, the left half-carcasses, were ground separately in an electric meat grinder (mouth 10 with 8 mm disc) then sampled, in a total ranging from 100 to 200 g of edible portion, of the shoulder, per age. The sample size varied because of the size of the cuts of the animals at 84 days. Samples were frozen at -5 ºC for further analysis of total lipids, cholesterol and fatty acids, which were done in triplicate.

The determination of total lipids or total fat was performed at Laboratório de Análises Químicas of Unidade Experimental de Caprinos e Ovinos (UECO) of UESB, Itapetinga, Bahia campus.

The total fat of the edible portion of each shoulder was determined by extraction with Soxhlet apparatus, using 1.0 to 2.0 g of sample in natural materials, in triplicate. According to the methodology of Santos-Cruz et al. (2008b) adapted from Silva (1981), the samples were packed in germitex paper and partially defatted with ethyl ether, in airtight container. After 12 hours, samples were removed from the container and put in an oven at 105 °C to obtain the dry weight of the partially-defatted sample and then sent to a Soxhlet extractor to obtain the residual fat. The total fat was measured by the sum of the partial and residual fats.

The steps of extraction and reading of the amount of cholesterol present in the edible portion of the shoulder were performed at Laboratório de Processamento e Qualidade da Carne and Laboratório of Bioquímica e Análise Instrumental, Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ/USP). The analysis by reverse-phase HPLC of samples of the edible portion of the lamb shoulder were performed according to the method described by Mazalli et al. (2003). After extraction, samples were injected in HPLC-Shimadzu liquid chromatograph with autosampler (SIL-10AF - Shimadzu Auto Sampler).

Extraction, methylation and reading to determine the fatty acid profile of edible portion of the shoulder were performed at the Laboratório de Nutrição Animal, Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ/USP).

For the analysis of the profile of fatty acids (FA) of lipids, the extraction was made using hexane:isopropanol (3:2), according to Hara & Radin (1978). After thawing, the samples were methylated according to Christie (1982). Transmethylated samples were analyzed by gas chromatography; model CG Focus - Finnigan, with a flame ionization detector, capillary column CP-Sil 88 (Varian), 100 m long, 0.25 mm in diameter and 0.20 mm film thickness. The fatty acid percentages were obtained by means of the software Chromquest (version 4.1).

The fatty acid profile was identified and quantified as percentages of the area, as well as SFA (sum of the mean percentage of peak areas of saturated fatty acids), UFA (sum of the mean percentage of peak areas of unsaturated fatty acids), MUFA (sum of the mean percentage of peak areas of monounsaturated fatty acids), PUFA (sum of the mean percentage of peak areas of polyunsaturated fatty acids), SFA:UFA ratio, MUFA:PUFA ratio and Hyper:Hippo (hypercholesterolemic (C14:0+C16:0) and hypocholesterolemic (monounsaturated + polyunsaturated) fatty acid ratio.

The design was randomized in a 4 × 2 factorial arrangement, with 4 ages (84, 168, 210, 252 days) and two sexual conditions (uncastrated and castrated male). For each age, 3 shoulders were cut from the left half carcass per lamb, representing one experimental unit. To study the effect of castration, age, their interaction, and correlation between lipids, cholesterol and fatty acids, features PROC GLM and PROC CORR of the software SAS (Statistical Analysis System, version 1.0) were utilized, considering the following statistical model: $Y_{ijk} = m + a_i + b_j + (ab)_{ij} + e_{(ij)k}$; in which: Y_{ijk} = values observed related to the i-th sexual condition and j-th age at slaughter, in the repetition k; m= mean effect; a_i = castration effect i (i=1,2); b_j = age at slaughter effect j (j=1,2,3,4); $(ab)_{ij}$ = effect of interaction between castration i and age at slaughter j; $e_{(ij)k}$ = random error to observation $Y_{ijk.}$

Results and Discussion

Body weight was not influenced by the effect of castration (P = 0.5021), i.e., castrated and uncastrated Santa Ines lambs, in general, had their body weight altered with advancing age at the same proportion or rate of growth. However, in early development, at 84 days, castrated lambs significantly exceeded (P = 0.0457) non-castrated lambs, with body weight of 25.66 kg and 18.20 kg, respectively. The body weight had a linear increase (P = 0.0001) with advancing age for castrated and non-castrated lambs (Table 1).

Considering the hormonal action caused by castration, which is the absence of testosterone, it was expected that castrate lambs had a greater weight than non-castrated lambs, since the absence of this hormone promotes less protein synthesis and hence, accumulation of fat in carcass and meat. However, this was not significantly verified (P = 0.5021) for body weight up to 252 days of age. Thus, castration is not necessary when planning to slaughter livestock such as lambs and young animals, since probably the development of secondary characteristics in uncastrated males is attributed to the production of testosterone, once

Table 1 - Mean values of body weight and shoulder weight of castrated and non-castrated Santa Inês lambs, at different ages

Effect of castration	Age at slaughter (days)					
	84	168	210	252	X general	Pr > | t |
			Body weight (kg)			
Castrated	25.66 (0.98)*	24.33 (2.02)	29.53 (2.32)	28.00 (2.80)	26.88	0.5021
Non-castrated	18.20 (1.83)	24.40 (2.30)	27.20 (1.40)	33.00 (4.29)	25.70	
Pr > | t |	0.0457	0.9848	0.5080	0.1661		Pr > | F |
X general BW	21.93	24.36	28.36	30.50	26.29	0.0001
Effect of castration		Age at slaughter (days)				
	84	168	210	252		
			Slaughter weight (kg)		X general	Pr > | t |
Castrated	0.781 (0.02)*	0.631 (0.06)	0.785 (0.07)	0.705 (0.08)	0.725	0.6371
Non-castrated	0.496 (0.06)	0.633 (0.08)	0.780 (0.07)	0.891 (0.10)	0.700	
Pr > | t |	0.0159	0.9876	0.9629	0.0965		Pr > | F |
X general BW	0.639	0.632	0.782	0.798	0.725	0.0465

** P<0.01; *P<0.05.
Body weight = castrated: y´= 23.33 + 0.02 × (R^2 = 37.75) with P = 0.0393; NC: y´= 10.59 + 0.08 × (R^2 = 97.41) with P = 0.0017.
Slaughter weight = castrated: y´= 0.725 (ns) with P = 0.8215; NC: y´= 0.278 + 0.002 × (R^2 = 97.21) with P = 0.0110.
Total N = 24.
X general BW - overall average body weight; X general - overall mean.

it is a promoter of growth and skeletal muscle, and this effect is accentuated after puberty.

Castrated and uncastrated lambs showed similar results for body weight at slaughter for ages 168, 210 and 252 days, indicating that there is no need to castrate young animals to stimulate production traits. Klein Jr. et al. (2008), working with castrated and uncastrated crossbred lambs in the short and long photoperiods, slaughtered at 37 kg body weight, found a greater amount of total fat in castrated animals and more connective tissue in non-castrated. However, there were no differences in weight of the full palette, muscle, subcutaneous fat and intramuscular fat.

The weight of lamb shoulders was higher (P = 0.0159) at 84 days (0.781 kg); there are no differences between castrated and non-castrated lambs at 168, 210 and 252 days. In general, castrated lambs up to 252 days of age probably partition the ingested nutrients to the tissues in a similar way, or to the palette, for being a cut with late growth rate. However, Santos-Cruz et al. (2001a), working with non-castrated lambs, verified that the shoulder presents growth proportional to body weight, i.e., with the increase in body weight and/or age of the animal, the shoulder weight also increases. Similar results were found in this study with non-castrated animals that, at 84 days, weighted 0.496 kg, reaching 0.891 kg at 252 days - almost the double of the development of the cut.

With the adjustment of general mean values of body weight and half carcass weight, there was a linear adjustment up to 252 days of age, i.e., with advancing age there was an increase in body weight (Figure 1). This increase has different rates during periods of growth, because at certain ages there might be higher, little or no change in the composition of the gain of the animals, directly influencing the development of different body parts or the whole.

For castrated lambs, there was no adjustment for the observed data, and the average shoulder weight was 0.725 kg from 84 to 252 days of age; therefore, castration did not influence cut weight.

Castration had an effect at 84, 168 and 210 days of age, in which castrated lambs presented, in the edible portion

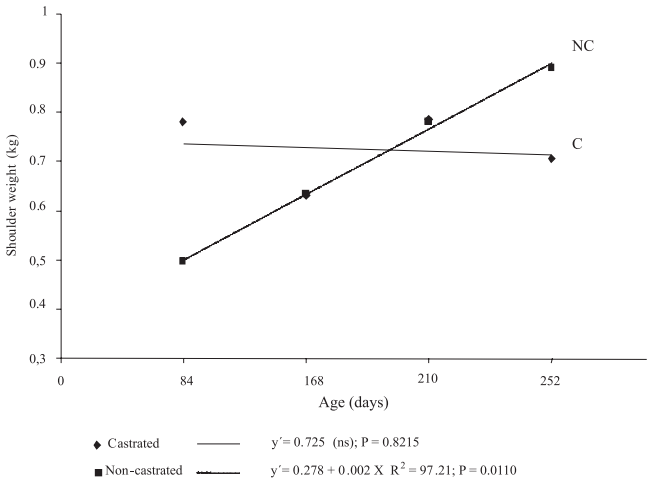

Figure 1 - Shoulder weight of castrated (N) and non-castrated (NC) Santa Inês lambs, at different ages.

of the shoulder, high levels of lipids: 15.49, 18.58 and 16.22 g/100 g, respectively (Table 2).

The values of total lipids ranged from 14.08 to 15.49% for castrated lambs and 10.48 to 14.91 for non-castrated lambs. The shoulder total lipid values are probably high because the portion considered edible, muscle and fat of the cut were used for the analysis.

Overall, castrated lambs presented mean value of 16.09 g/100 g of total lipids in relation to non-castrated lambs (11.95 g/100 g), probably because of their metabolism, which requires a greater amount of fat. The same was observed by Kemp et al. (1972), evaluating the quality of lamb meat from Hampshire castrated and slaughtered at 36, 45 and 54 kg live weight.

However, according to Vergara et al. (1999), who studied the influence of sex and slaughter weight on the carcass traits of 21 and 27 kg Breed Manchega, the difference between castrated and non-castrated lambs, as regards the centesimal composition of the meat, is not so big, especially if one considers the growth period studied.

The shoulders of castrated and non-castrated lambs presented lipid values higher than those determined by

Table 2 - Mean values of total lipids (g/100 g) of castrated and non-castrated Santa Inês lambs at different ages

Effect of castration	Age at slaughter (days)				X general	Pr > | t |
	84	168	210	252		
Castrated	15.49 (0.97)**	18.58 (1.11)**	16.22 (2.17)*	14.08 (0.39)	16.09**	0.0001
Non-castrated	10.48 (0.20)	10.91 (0.47)	11.49 (0.24)	14.91 (1.79)	11.95	
Pr > | t |	0.0073	0.0002	0.0104	0.6149		Pr > | F
X general	12.99	14.74	13.85	14.49	14.02	0.0013

** P<0.01; *P<0.05.
Castrated: y´= 6.19 + 0.15 x – 0.0004 X^2 (R^2 = 84.86) with P = 0.0374.
Non-castrated: y´ = 7.87 +0.022 X (R^2 = 78.74) with P = 0.0162.
Total N = 24.
X general - overall mean.

Madruga et al. (2005), who found values from 6.93 to 8.38 g/100 g analyzing the cut "leg" of 24 non-castrated Santa Inês lambs with average weight of 18.5 kg and fed different diets. This might have happened probably because the leg, unlike the shoulder, is a cut that has a greater amount of muscle than deposited fat, so it probably has more protein in proportion to the amount of total lipids.

The carcass and, consequently, its regional composition are changed by excess deposition of fat, which was observed in this experiment by the effect of castration on the edible portion of the shoulder due to lack of testosterone production. However, at 252 days of age, castrated lambs showed the same (P = 0.6149) total lipid content as non-castrated animals: 14, 08 and 14.91 g/100g, respectively. This means that castration is a technique discarded when producing lambs, i.e., animals aged 252 days or more, since at any given time, there will be the need to supply large quantities of diet, but the conversion will be inefficient.

The amount of total lipids of edible portion tended to show a quadratic response for castrated lambs (Figure 2), i.e., 184.5 days of age was the point of maximum deposition of lipids in the shoulder, while in non-castrated lambs there was a linear increase; therefore, fat deposition continued to increase with age.

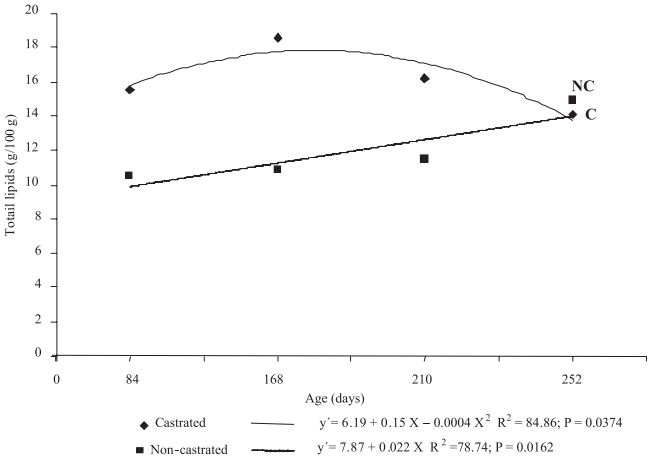

Figure 2 - Total lipids of castrated and non-castrated Santa Inês Lamb shoulders, at different ages.

Santos-Cruz et al. (2008a), evaluating the effect of sex on the carcass composition of lambs observed higher levels of ether extracts and energy for castrated males and females, while males had higher amounts of crude protein and ash.

The edible portion of the shoulder, part that actually is traded, has higher fat content than the muscular portion of the cut; so for assessment of human nutrition, one must consider what is actually ingested by the consumer.

The edible portion of the shoulder of castrated lambs until 210 days of age possessed greater quantities of total lipids in g/100 g, and in the range from 168 to 210 days, there was a high peak of deposition. However, Santa Ines non-castrated lambs presented smaller quantities of lipids in the shoulder, with fast deposition rate after 210 days of age.

Castrated lambs presented, in the edible portion of the shoulder, higher cholesterol contents than non-castrated lambs at the ages of 84, 168, 210 and 252 days (Table 3).

According to Johnson et al. (1995), castration has no effect on the cholesterol content of goat meat, but in this experiment, when the edible portion of the shoulder was analyzed, it could be affirmed that castration has effect (0.0001) on the cholesterol content of sheep meat, and that there are changes in the composition with advancing age.

Total cholesterol levels in sheep meat can vary greatly, because the maturity of the sheep may be one factor, as well as the portion analyzed, sex, diet and species analyzed. Rebello (2003) mentions that variations in cholesterol content, among the various existing studies, may be related to the diet, place of sample collection, age, breed and the methodology used for the determination itself.

From 84 to 252 days of age, the values varied from 75.30 to 68.38 mg/100 g for castrated lambs, while for non-castrated lambs the variation ranges from 62.74 to 53.94 mg/100 g, i.e., aging had a decreasing linear effect on cholesterol contents (Figure 3). Pérez et al. (2002), working with non-castrated Santa Inês lambs observed higher cholesterol contents when the animals reached 35 kg of body weight.

Table 3 - Mean values of cholesterol (mg/100 g) of shoulders of castrated and non-castrated Santa Inês lambs, at different ages

Effect of castration	Age at slaughter (days)				X general	Pr > | t |
	84	168	210	252		
Castrated	75.30 (2.73)**	71.48 (0.95)**	74.91(0.32)**	68.38 (2.56)**	72.52**	0.0001
Non-castrated	62.74 (0.88)	58.72 (2.02)	64.30 (0.09)	53.94 (1.28)	59.94	
Pr > | t |	0.0001	0.0001	0.0003	0.0001		Pr > | F |
X general	69.02	65.10	69.60	61.19	66.23	0.0001

** P<0.01.
Castrated: y´= 78.08 - 0.031 X (R^2 = 47.43) with P = 0.0313.
Non-castrated: y´ = 66.32 – 0.035 X (R^2 = 33.51) with P = 0.0125.
Total N = 24.
X general - overall mean.

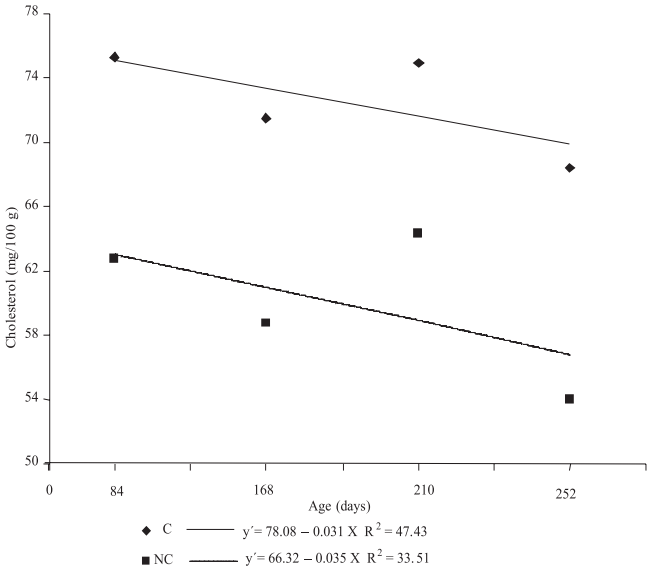

Figure 3 - Cholesterol contents of the shoulder of castrated (C) and non-castrated (NC) Santa Inês lambs, at different ages.

Madruga et al. (2005), when evaluating the quality of meat from confined non-castrated Santa Inês lambs fed different diets, reported cholesterol values from 44.10 mg/100 g to 57.80 mg/100 g on lamb leg. These values are lower than those found in this research for the edible part of shoulders of castrated and non-castrated lambs, raised on pasture, so one can say that the production system is not the only factor that causes changes in the composition of meat. However, practices such as castration also influence both positively and negatively.

Castration positively influenced the cholesterol content of the shoulder; however, both castrated and non-castrated lambs had their cholesterol decreased with age increase.

Effect of castration and age was observed on the concentrations of lauric (C12:0), myristic (C14:0), palmitic (C16:0), stearic (C18:0) and myristoleic (C14:1 C9) acids (Table 4).

The myristoleic acid (C14:1 C9) presented quadratic adjustment for the concentrations determined in the edible portion of castrated lambs shoulder, with inflexion at 164.8 days of age, with 0.1417 g.100 g^{-1} of C14:1 C9), while for the shoulder of non-castrated lambs there was no adjustment of concentration values, which were, on average 0.1808 g.100 g^{-1} of C14:1 C9 at different ages at slaughter.

In general, saturated acids increase cholesterol; the myristic acid (C14:0) influences the most, followed by palmitic (C16:0) and lauric (C12:0) acids. Scientific studies showed that lauric acid does not increase the cholesterol levels as previously thought, but quite the opposite: they elevate the levels of good cholesterol (HDL) in the blood (Enig, 1998; Kaunitz & Dayrit, 1992). Lauric acid reduces the oxidation of bad cholesterol (LDL) in the blood, preventing cardiovascular disease, and reduces carbohydrate cravings due to not stimulating insulin release. Thus, the presence of lauric acid in meat of lambs may be indicative of a healthier type of meat.

Stearic acid (C18:0) is considered a neutral acid because it increases the concentration of LDL cholesterol, and for this reason, it can be compared to monounsaturated acids.

The highest concentration of C12:0 (0.97 g.100 g^{-1}) was observed in shoulders of non-castrated lambs at 84 and 168 days of age, with a decreasing linear effect (Figure 4). The same adjustment was observed for castrated lambs, in which the shoulder reached the concentrations of 0.40 g.100g^{-1} at 210 days and 0.36 g.100g^{-1} at 252 days of age.

The lauric acid (C12: 0) does not increase the cholesterol levels, but can balance the levels of good cholesterol (HDL) in the blood; thus, the high levels of cholesterol determined in the edible portion of the shoulder of castrated lambs can be related to the presence of LDL. However, this is a hypothesis, because the fractioning was not performed in the cholesterol found, i.e., the determination in the blood plasma of lambs of LDL and HDL, from 84 to 252 days.

The shoulders of non-castrated lambs presented a higher level (7.95 g.100 g^{-1}) of myristic acid concentration (C14:0), when lambs were 133.3 days old. A quadratic effect was observed when the age at slaughter increased (Figure 5). At 84 days old, castrated lambs presented higher concentrations of myristic acid in the shoulder (8.32 g.100 g^{-1}).

Table 4 - Regression equations of the interaction of effects of castration with age on the profile of fatty acids on the shoulder of Santa Ines lambs

Fatty acids	Castrated		Non-castrated	
	RE	R^2	RE	R^2
C12:0	$y´= 1.072 – 0.003x$	56.86	$y´= 1.365 – 0.003x$	53.75
C14:0	$y´= 9.3837 – 0.020x$	50.18	$y´= 2.62 + 0.08\ x – 0.0003\ x^2$	59.21
C16:0	y´= 25.59 (ns)	-	y´= 25.42 (ns)	-
C18:0	$y´= 6.469 – 0.344x + 0.0009x^2$	54.13	$y´= 10.51 + 0.05x$	56.93
C14:1 C9	$y´= 0.3890 – 0.003x + 9.1x10^{-6}\ x^2$	49.33	y´= 0.1808 (ns)	-

RE - regression equation; C12:0 - lauric acid C14:0 - myristic acid; C16:0 - palmitic acid; C18:0 - stearic acid; C14:1 C9 - myristoleic acid.

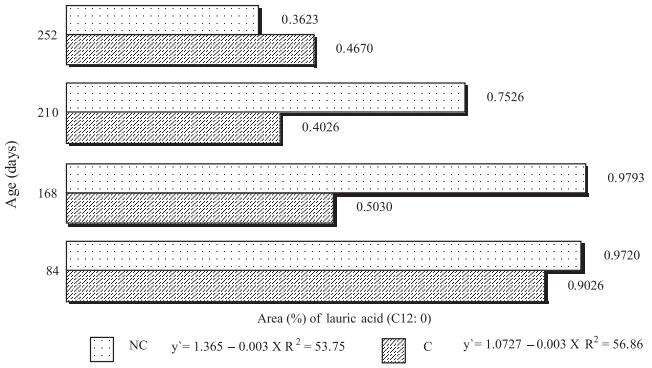

Figure 4 - Percentage area of lauric acid (C12:0) in castrated (C) and non-castrated (NC) Santa Inês lambs, at different ages.

Among the saturated fatty acids, the myristic acid (C14:0) seems to be the main cause of the increase of LDL cholesterol in humans, when compared with lauric and palmitic acids; however, these data are not entirely consistent (Kris-Etherton & Yu, 1997; Temme et al., 1996). However, considering this information, the shoulder of non-castrated lambs must not be consumed due to the high concentration of myristic acid (6.96 g.100 g^{-1}). The myristic acid is a saturated fatty acid that occurs in most animal fats and tends to raise the LDL and is among the chain acids with 10 to 18 carbons, one of the most atherogenic, or harmful to human health, by raising cholesterol levels.

Stearic acid (C18:0) (Figure 6) presented quadratic adjustment in castrated lambs, and at 191.1 days of age the edible portion of the shoulder presented the maximum value of 26.40 g.100 g^{-1}. However, non-castrated lambs showed an increase of stearic acid in the shoulder with age. At 84 days of age the concentrations of C18:0 in the shoulder of castrated and non-castrated lambs was similar: 15.56 and 15.61 g.100 g^{-1}, respectively. However, at 168 and 210 days of age, the shoulders of castrated lambs presented higher amounts of C18:0; 20.05 and 22.56 g.100 g^{-1}, respectively, in relation to non-castrated lambs, whose values were higher at 252 days of age (24.99 g.100 g^{-1}). These results allow concluding that the effects of castration and age interfere with the concentrations of stearic acid in lamb shoulders.

The correlation between the contents of total lipids, cholesterol and saturated and unsaturated fatty acids in the edible portion of the shoulders of castrated (Table 5) and non-castrated (Table 6) lambs, at different slaughter ages, allowed inferring that there was a highly significant negative correlation (-0.99) between SFA and UFA, for lambs castrated at 210 days of age, i.e., in this age group the concentrations of saturated acids interfere with the concentrations of unsaturated acids. At 210 days of age, as there is increased concentration of saturated fatty acids, the unsaturated ones are reduced. However, in non-castrated lambs at 168 days of age, cholesterol levels are influenced by the concentrations of unsaturated fatty acids; thus, lamb shoulder at this age is rich in HDL, and does not damage health.

There was no influence of lipids contents on cholesterol levels, according to the correlation study, i.e., at the studied ages, the sexual condition did not influence changes of nutrients in the muscles and adipose tissues, once again showing that castration is not necessary when lambs are bred for meat production. However, Vicente Neto et al. (2006) claims that the cut with the lowest cholesterol value presents higher values of total lipids, regardless of the origin.

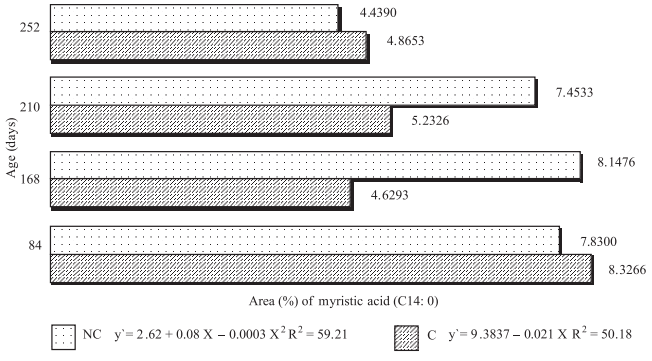

Figure 5 - Percentage area of myristic acid (C14:0) in castrated (C) and non-castrated (NC) Santa Inês lambs, at different ages.

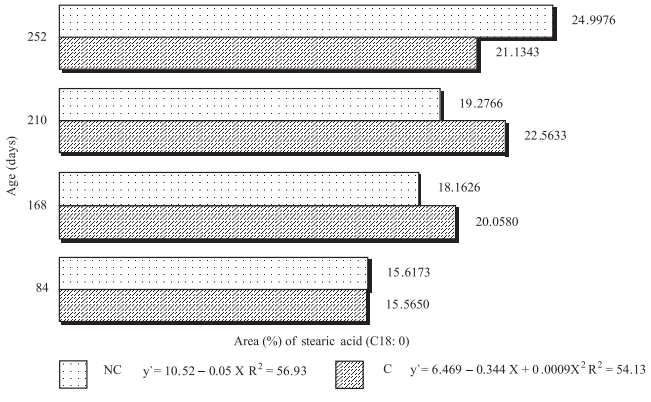

Figure 6 - Percentage area of stearic acid (C18:0) in castrated (C) and non-castrated (NC) Santa Inês lambs, at different ages.

Table 5 - Correlation of total lipids (LIP), cholesterol content (COL), proportion of saturated fatty acids (SFA) and unsaturated fatty acids (UFA) in castrated lambs, at different ages

	Age at slaughter (days)							
	84				168			
	LIP	COL	SFA	UFA	LIP	COL	SFA	UFA
LIP	1.00	0.70	0.90	-0.85	1.00	0.74	-0.41	0.18
COL	0.70	1.00	0.30	-0.20	0.74	1.00	0.92	0.79
SFA	0.90	0.30	1.00	-0.99	-0.41	-0.92	1.00	-0.97
UFA	-0.85	-0.20	-0.99	1.00	0.18	0.79	-0.97	1.00
	Age at slaughter (days)							
	210				252			
	LIP	COL	SFA	UFA	LIP	COL	SFA	UFA
LIP	1.00	-0.55	-0.97	0.98	1.00	0.73	0.27	-0.43
COL	-0.55	1.00	0.33	-0.36	0.73	1.00	0.86	-0.93
SFA	-0.97	0.33	1.00	-0.99*	0.27	0.86	1.00	-0.98
UFA	0.98	-0.36	-0.99*	1.00	-0.43	-0.93	-0.98	1.00

* r<0.05.

Table 6 - Correlation of total lipids (LIP), cholesterol (COL) content, proportion of saturated fatty acids (SFA) and unsaturated fatty acids (UFA) in non-castrated lambs, at different ages

	Age at slaughter (days)							
	84				168			
	LIP	COL	SFA	UFA	LIP	COL	SFA	UFA
LIP	1.00	0.60	-0.48	-0.40	1.00	-0.95	0.25	-0.95
COL	0.60	1.00	0.77	-0.97	-0.95	1.00	0.07	0.99**
SFA	-0.48	0.77	1.00	-0.89	0.25	0.07	1.00	0.06
UFA	-0.40	-0.97	-0.89	1.00	-0.95	0.99**	0.06	1.00
	Age at slaughter (days)							
	210				252			
	LIP	COL	SFA	UFA	LIP	COL	SFA	UFA
LIP	1.00	-0.15	0.70	-0.55	1.00	-0.44	-0.65	0.80
COL	-0.15	1.00	-0.83	0.91	-0.44	1.00	-0.40	0.19
SFA	0.70	-0.83	1.00	-0.99	-0.65	-0.40	1.00	-0.97
UFA	-0.55	0.91	-0.99	1.00	0.80	0.19	-0.97	1.00

**r<0.01.

It is worth stressing that the edible portion of the shoulder has lipids with functional membranes and that, according to Hood (1987), the lipids of the functional membranes contain higher concentrations of cholesterol than the lipids of intramuscular adipose tissue, partially considered for the lipid characterization.

Conclusions

Castrated Santa Inês lambs, under semi-extensive conditions, present higher amounts of C18:1 T11 and conjugated linoleic acids in the edible portion of the shoulder. Castration does not cause significant correlation between total lipids, cholesterol and total saturated and unsaturated fatty acids in the edible portion of Santa Inês lambs from 84 to 252 days of age.

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