Asian-Aust. J. Anim. Sci.
Vol. 24, No. 10 : 1399 - 1406
October 2011

www.ajas.info
http://dx.doi.org/10.5713/ajas.2011.11110

Meat Quality of Lambs Fed on Palm Kernel Meal, a By-product of Biodiesel Production*

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ABSTRACT : This study aimed to establish the optimum level of palm kernel meal in the diet of Santa Inês lambs based on the sensorial characteristics and fatty acid profile of the meat. We used 32 lambs with a starting age of 4 to 6 months and mean weight of 22 ±2.75 kg, kept in individual stalls. The animals were fed with Tifton-85 hay and a concentrate mixed with 0.0, 6.5, 13.0 or 19.5% of palm kernel meal based on the dry mass of the complete diet. These levels formed the treatments. Confinement lasted 80 days and on the last day the animals were fasted and slaughtered. After slaughter, carcasses were weighed and sectioned longitudinally, along the median line, into two antimeres. Half-carcasses were then sliced between the 12th and 13th ribs to collect the loin (longissimus dorsi), which was used to determine the sensorial characteristics and fatty acid profile of the meat. For sensorial evaluation, samples of meat were given to 54 judges who evaluated the tenderness, juiciness, appearance, aroma and flavor of the meat using a hedonic scale. Fatty acids were determined by gas chromatography. The addition of palm kernel meal to the diet had no effect on the sensorial characteristics of meat juiciness, appearance, aroma or flavor. However, tenderness showed a quadratic relationship with the addition of the meal to the diet. The concentration of fatty acids C12:0, C14:0 and C16:0 increased with the addition of palm kernel meal, as did the sum of medium-chain fatty acids and the atherogenicity index. Up to of 19.5% of the diet of Santa Inês lambs can be made up of palm kernel meal without causing significant changes in sensorial characteristics. However, the fatty acid profile of the meat was altered. (**Key Words :** By-products, Fatty Acids, Organoleptic, Palmist, Ruminants)

INTRODUCTION

Northeast Brazil is home to 56.4% of the national sheep population. Sheep farming plays a major socio-economic role in the region and is mainly focused on meat production (Anualpec, 2006). However, the domestic consumption of sheep meat in Brazil is still considered low in comparison to other countries. Various factors are related to the low use of sheep meat, the most important ones being inconsistent supply and carcasses without patterning and fat excess (Ferrão et al., 2009). According to Zapata et al. (2000), qualitative aspects may also reduce consumption, such as the odor and active taste, typical of animals slaughtered later.

The quality of meat depends on the combination of various attributes such as flavor, appearance, nutritional composition and even the microbiological safety of the final product (Webb et al., 2005). Flavor can be scored by sensorial evaluation and tenderness is considered by consumers to be the most important characteristic of meat (Safari et al., 2001). At the time of purchase, the appearance of the product is the main factor considered (Costa et al., 2008).

In relation to nutritional composition, the fatty acid profile is of great interest, because meat is a source of fat in the diet, especially saturated fatty acids that have been linked to coronary heart disease (Wood et al., 2003).

Factors such as breed, age at slaughter, diet and the production system have an influence on meat quality (Silva

* The work was supported by the Fundação de Amparo à Pesquisa do Estado da Bahia - FAPESB, Salvador, Bahia, Brazil.
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Received April 20, 2011; Accepted June 7, 2011

Sobrinho and Silva, 2000; Bonacina et al., 2011). Of these, nutrition is particularly important, because changes in the diet can improve both the quantity and the quality of the final product (Johnson and McGowan, 1998; Geay et al., 2001; Batista et al., 2010). Feed is the biggest cost in livestock production and the use of alternative foods, such as by-products of biodiesel, may be a viable alternative, both in economic and nutritional terms (Silva et al., 2007).

Palm kernel meal is the product of oil extraction from the fruit of the Palm (*Elaeis guineensis*), which grows in northeast Brazil. At the end of productive chain of biodiesel, this meal is thrown away and can cause serious environmental damage. It is therefore important to evaluate its use in animal feed. Some works (Carvalho et al., 2004; Silva et al., 2005) have studied the effect of palm kernel meal in the diet of dairy goats, but no study evaluated the effect of this ingredient in the meat quality of lambs. Specific and novel ingredients of diets fed to finishing animals may also affect the taste of the meat (Lanza et al., 2001), but this is a little studied area.

In this context, the objective of this work was to determine the optimum level of palm kernel meal in the diet of lambs according to the sensorial characteristics and fatty acids profile of the meat.

MATERIAL AND METHODS

General procedure

The experiment was conducted in the School of Veterinary Medicine, Federal University of Bahia in Salvador, Bahia.

Thirty-two uncastrated male Santa Inês lambs, aged between 4 and 6 months and weighing 22±2.75 kg, which had been dewormed and vaccinated against clostridial diseases, were used. The animals were housed individually in pens measuring 1.0×1.0 m, on a suspended wooden floor, and were provided with water troughs and feeders. The experimental period lasted 80 days and was preceded by 10 days of animal adaptation to the environment, management and diets.

Diets

The concentrate was composed of palm kernel meal, corn meal, soybean meal and minerals. The chemical composition of the ingredients is shown in Table 1. Palm kernel meal was added to the diet at levels of 0.0, 6.5, 13.0, and 19.5% total dry matter (Table 2). The diets were formulated according to NRC (1985) recommendations and were isonitrogenous and isocaloric (Table 2).

Roughage was supplied as Tifton-85 hay (*Cynodon* sp.) ground into particles of about 5 cm. The animals were fed twice daily with a total mixed ration. The proportion of concentrate and roughage was 50:50. Enough food was supplied to ensure that between 10% and 15% remained after feeding. Water was supplied *ad libitum*.

Each ingredient in the total mixed ration was collected and the samples were analyzed in triplicate to determine the chemical composition. The chemical composition of the diet ingredients was determined according to the AOAC (1990) for dry matter (DM), ash, crude protein and ether extract. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to Van Soest et al. (1991). Lignin was obtained by treatment of ADF residue with sulphuric acid (72%) follow Van Soest (1963). Neutral detergent insoluble nitrogen and acid detergent insoluble nitrogen was obtained according to Licitra et al. (1996). The non-fibrous carbohydrates were calculated according to Mertens (1997). Total digestible nutrients (TDN) were

Table 1. Chemical composition (% DM) of ingredients in diets fed to Santa Inês lambs

Item	Ingredient			
	Corn	Soybean meal	Palm kernel meal	Tifton-85 hay
Dry matter (%)	88.68	89.73	95.29	93.37
Organic matter	98.97	93.57	96.67	93.34
Ash	1.03	6.43	3.33	6.66
Crude protein	4.53	46.52	16.64	8.28
ADIN (% total N)[1]	6.00	2.00	20.00	16.00
NDIN (% total N)[2]	20.00	8.00	43.00	53.00
Neutral detergent fiber	12.12	11.29	70.04	83.65
Acid detergent fiber	3.70	8.16	45.71	45.32
Lignin	1.06	0.65	15.72	13.15
Cellulose	2.64	7.51	29.99	32.17
Hemicellulose	8.42	3.13	24.33	38.33
Non-fibrous carbohydrates	79.31	33.15	2.21	0.79
Ether extract	3.01	2.61	7.78	0.62

[1] Acid detergent insoluble nitrogen. [2] Neutral detergent insoluble nitrogen.

Table 2. Proportion of ingredients, bromatological composition and fatty acid profile of experimental diets fed to Santa Inês lambs

Ingredient (% DM)	Palm kernel meal (% DM)			
	0.00	6.50	13.00	19.50
Corn	37.38	32.36	27.16	21.78
Soybean meal	11.12	9.84	8.52	7.15
Palm kernel meal	0.00	6.30	12.82	19.57
Minerals[1]	1.50	1.50	1.50	1.50
Tifton-85 hay	50.00	50.00	50.00	50.00
Chemical composition (% DM)				
Dry matter (%)	91.34	91.70	92.12	92.56
Ash	4.43	4.50	4.58	4.66
Crude protein	11.00	11.23	11.46	11.70
Ether extract	1.72	2.03	2.34	2.67
Neutral detergent fiber	47.60	51.26	55.05	58.97
Acid detergent fiber	24.89	27.49	30.18	32.96
Lignin	7.52	8.40	9.30	10.23
Cellulose	17.37	19.09	20.87	22.72
Hemicellulose	22.71	23.77	24.87	26.01
Non-fibrous carbohydrates	35.22	30.96	26.54	21.97
Total digestible nutrients	70.01	73.89	70.49	75.56
Fatty acid profile (% total of fatty acids)				
C12:0	0.06	6.19	12.55	19.12
C14:0	0.25	2.26	4.34	6.49
C16:0	17.45	16.39	15.29	14.16
C18:0	4.45	4.17	3.88	3.59
Other saturated fatty acids	0.35	1.45	2.59	3.77
C18:1 *n-9*	24.15	22.30	20.40	18.42
C18:1 *n-6*	0.48	0.46	0.43	0.41
C18:2 *n-6*	47.15	41.19	35.02	28.63
C18:3 *n-3*	2.36	2.12	1.87	1.62
Other unsaturated fatty acids	2.80	3.03	3.26	3.50
SCFA[2]	0.01	1.14	2.31	3.52
MCFA[3]	18.22	25.26	32.55	40.09
LCFA[4]	81.77	73.60	65.14	56.38

calculated from the proportion of digestible nutrients, as show in equation: TDN = (Digestible Crude Protein+ Digestible Neutral Detergent Fibre+Digestible Non-Fibrous Carbohydrates+(2.25×Digestible Ether Extract)), according to Weiss (1999). The digestible coefficients were obtained from a digestibility trial. The chemical composition of diets was calculated with data obtained by chemical analysis of the ingredients. To extract fatty acids present in the ingredients for later analysis using a gas chromatograph, the methodology described by Rodríguez-Ruiz et al. (1998) was used. The fatty acid profiles of ingredients are shown in Table 2.

Slaughtering

At the end of the experiment, animals were fasted for 16 hours and slaughtered, at a mean body weight of 36.61±1.6 kg. After slaughter the animals were skinned and eviscerated and their carcasses were refrigerated (4°C) for 24 h. After this period, carcasses were weighed and sectioned longitudinally into two antimeres. The longissimus dorsi (the section between the last lumbar and the first sacral vertebrae) were collected, according to the methodology of Colomer-Rocher et al. (1987). These cuts of meat, two per animal, were labeled and frozen immediately after collection for later measurement of the fatty acid profile and the assessment of sensory characteristics.

Sensory analysis

For sensory analysis, the samples of meat were thawed, grouped by treatment, and cut into cubes of 3 cm^3, to which 0.75% (relative to the weight of the meat) salt (sodium chloride) was added. Samples were then placed into a baking dish, covered with aluminum foil and roasted in a preheated oven at 200°C until the internal temperature reached 75°C.

After roasting, the meat was transferred to a container in a hot water bath until sensory evaluation. The sensorial analysis was performed by a team of 54 judges, who were chosen at random after being informed about which parameters they should evaluate and how to use the scoring system. The assessment was conducted in individual cabins in which there were samples from all treatments, served on paper plates, and an evaluation form with the parameters to be scored. Mineral water was provided at room temperature to remove the residual taste between the samples. The samples were evaluated in relation to appearance, odor, flavor, tenderness and juiciness, each of these parameters being scored using a hedonic scale from 1 to 9, where 1 refers to the least favorable and 9 refers to the most favorable condition (Minim, 2006).

Fatty acids profile analysis

Fatty acids were extracted and methylated from the meat using methods described by Hara and Radin (1978).

After extraction and methylation, each sample was injected (1 ml) into a Finnigan GC Focus gas chromatograph, equipped with a flame ionization detector, capillary column CP-Sil 88 (Varian), and 100-m long, 0.25-μm diameter and 0.20-μm thick film. Hydrogen was used as the carrier gas at a flow rate of 1.8 ml/min. The initial oven temperature was held at 70°C for 4 min, after which it was increased to 175°C (13°C/min) and held at that temperature for 27 min, then increased to 215°C (40°C/min) and held for 9 min, and finally increased by 7°C/min to 230°C and held for 5 min, totaling 65 min. The vaporizer temperature was 250°C and the detector temperature was 300°C. Fatty acids were identified by comparison of the retention times of methyl esters of the samples with a predefined pattern, and then quantified by normalizing the areas of methyl esters; the results are expressed in percentage area (%).

Based on the fatty acid profile, we calculated the atherogenicity index (AI), a parameter that was proposed by Ulbricht and Southgate (1991) and that is positively correlated with the risk of cardiovascular disorders. The calculation was carried out as follows:

$$AI = (C12:0+(C14:0\times4)+C16:0) / (\text{Total unsaturated fatty acids})$$

We also calculated the proportions of total saturated (Sat) and unsaturated (Unsat) fatty acids, omega-6 (n-6), and omega-3 (n-3).

Statistical analysis

Initially, all variables had their normality and homogeneity of variance assessed by residual plots. Then, data were analysed using one-way analysis of variance with the General Linear Model procedure of the Statistical Analysis System package (SAS® 9.1.3) according to the model:

$$y_{ij} = \mu+\tau_j+e_{ij}$$

Where y_{ij} is the dependent variable of the *ij*th animal, μ the overall mean, τ_j the fixed effect of the *i*th level of palm kernel meal and e_{ij} is the random error. Significance was defined at $p<0.05$. Regression test was done using Regression Procedure of the Statistical Analysis System package (SAS® 9.1.3). The tendency linear or quadratic was chosen by their significance level (p value).

RESULTS AND DISCUSSION

Sensorial characteristics

The sensorial analysis indicated the high acceptability of the product, because the average score of each attribute was higher than 5. The sensorial characteristics of the meat (appearance, flavor, smell and juiciness) were not affected by the addition of palm kernel meal to the diet (Table 3).

The appearance of the meat is directly related to its color and this is an indication to the consumer of its quality and freshness. In this study, the average score for appearance was 6.5, which translates to "slightly attractive" to "moderately attractive". The values found in this study were similar to those reported by Pinheiro et al. (2008),

Table 3. Sensorial characteristics, evaluated on a scale of 1 to 9, of the meat of Santa Inês lambs fed diets containing different levels of palm kernel meal

Variable	Level of palm kernel meal				RSD[1]	Significance
	0.00	6.50	13.00	19.50		
Appearance	6.5	6.7	6.5	6.6	1.659	ns
Smell	6.9	7.3	6.9	6.6	1.599	ns
Flavor	7.0	7.3	7.0	6.7	1.667	ns
Juiciness	6.2	6.6	6.7	6.4	1.504	ns

[1] Residual standard deviation; ns = not significant; * p<0.05; ** p<0.01.

who evaluated the color of meat from uncastrated lambs, and Siqueira et al. (2002), who assessed the appearance of meat from Santa Inês lambs slaughtered at an average weight similar to that in this study.

Dark meat is generally rejected by consumers, who associate it with older meat or meat from mature animals, and thus tough meat (Bressan et al., 2001). According to Madruga et al. (2005), high pH values can lead to darker meat, and Geay et al. (2001) contend that the pH is strongly influenced by muscle glycogen stores at slaughter and the rate of cooling of the meat.

In this study, all animals were subjected to the same period of fasting prior to slaughter, and thus all experienced similar effects on the concentration of muscle glycogen. Thus, the glycogen concentrations were presumably similar in animals from the different treatment groups, which may explain why there was no difference in the final appearance of the meat.

Slaughtering animals at an older age also results in darker meat, because the concentration of myoglobin increases with the age of the animal (Andrade et al., 2009). In this study, animals were slaughtered at the same age and thus with similar concentrations of myoglobin.

Flavor is of primary importance among the attributes that make consumers buy and consume lamb (Sañudo, 2008). According to the average values found in this study for flavor and smell (7.0 and 6.9), it was classified as moderately tasty meat. The similarity in the flavor and smell of the meat in this study is probably related to the concentration of short-chain fatty acids (Table 5), which were not influenced by the different levels of palm kernel meal in the diet.

According to Geay et al. (2001) and Webb et al. (2005), the juiciness of the meat may be influenced by the saliva produced during tasting. In this manner, attributes that stimulate salivation (appearance, smell and flavor) can also interfere in juiciness. In this study there were no differences in any of these attributes, a fact that may explain the similarity in values for juiciness among treatments.

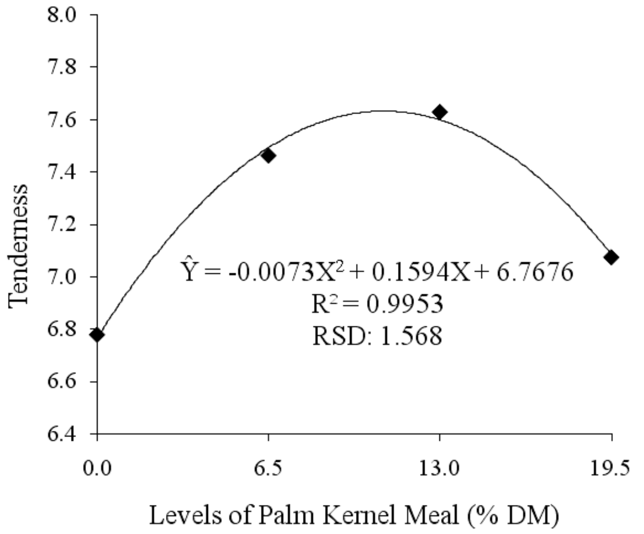

Figure 1. Tenderness evaluated using a hedonic scale of 1 to 9 of meat of Santa Inês lambs fed with different levels of palm kernel meal.

The addition of palm kernel meal in the diet led to a quadratic ($\hat{Y} = -0.0073x^2+0.1594x+6.7676$) relationship ($p<0.05$) for tenderness (Figure 1), with a maximum value of 7.63 for the 10.92% level of palm kernel meal.

Fatty acids profile

With regard to the fatty acid profile, the addition of palm kernel meal increased the concentration of C12:0 and C14:0 in the diet (Table 2), and this was reflected in the increase in the level of these fatty acids in the meat (Table 4).

There was a linear increase ($p<0.05$) in the concentration of palmitic acid (C16:0) in the muscle of

Table 4. Fatty acids as a percentage of total fatty acids in meat of Santa Inês lambs fed diets containing different levels of palm kernel meal

Item	Level of palm kernel meal (%)				RSD[1]	Regression equation	R²
	0.00	6.50	13.00	19.50			
C12:0	0.10	0.23	0.37	0.54	0.184	$\hat{Y} = 0.02X^{**}+0.06$	0.50
C14:0	2.23	3.27	3.94	4.60	1.119	$\hat{Y} = 0.12X^{**}+2.25$	0.46
C16:0	23.26	24.60	25.23	24.80	1.435	$\hat{Y} = 0.06X^{*}+24.34$	0.11
C18:0	14.99	17.17	16.45	15.31	2.152	ns	-
Other Sat.	4.22	3.38	3.05	3.05	0.982	$\hat{Y} = 4.232-0.072X^{**}$	0.23
C16:1 *cis-9*	3.04	2.86	3.04	3.27	0.295	ns	-
C18:1 *cis-9*	41.07	37.43	39.86	37.86	3.813	ns	-
C18:1 *trans*	1.19	1.26	0.76	0.84	0.588	ns	-
C18:2 *cis-9 cis-12*	2.66	2.33	2.71	1.52	1.002	$\hat{Y} = -0.06X^{*}+3.31$	0.33
Other Uns.	5.76	5.42	4.09	5.87	2.204	ns	-

[1] Residual standard deviation, ns = not significant; * $p<0.05$; ** $p<0.01$.

Table 5. Profile and fatty acid ratios as a percentage of total fatty acids in the meat of Santa Inês lambs fed diets containing different levels of palm kernel meal

Item	Level of palm kernel meal (%)				RSD[1]	Regression equation	R²
	0.00	6.50	13.00	19.50			
CLA	0.30	0.28	0.20	0.31	0.087	ns	-
Saturated	45.08	48.71	49.08	48.32	3.999	ns	-
Unsaturated	54.92	51.29	50.92	51.68	3.999	ns	-
Sat:Uns[2]	0.82	0.96	0.98	0.94	0.158	ns	-
n-3	0.32	0.34	0.30	0.24	0.133	ns	-
n-6	0.80	0.72	0.37	0.94	0.321	ns	-
n6:n3[3]	2.76	2.55	1.77	2.56	1.229	ns	-
AI[4]	0.59	0.75	0.83	0.86	0.170	$\hat{Y}$ = 0.01X**+0.61	0.35
SCFA[5]	0.20	0.15	0.18	0.15	0.058	ns	-
MCFA[6]	30.92	32.74	34.23	34.92	2.623	$\hat{Y}$ = 0.22X**+ 31.37	0.35
LCFA[7]	68.89	67.10	65.59	64.94	2.639	$\hat{Y}$ = -0.22X**+ 68.47	0.35

[1] Residual Standard Deviation. [2] Ratio between saturated and unsaturated fatty acids. [3] Ratio between n-3 and n-6 fatty acids.
[4] Atherogenicity index. [5] Short-chain fatty acids (below 11 carbons). [6] Medium-chain fatty acids (11 to 16 carbons).
[7] Long-chain fatty acids (up to 16 carbons); ns = not significant; * p<0.05; ** p<0.01.

lambs (Table 4). This increase may be related to an increase in ether extract intake ($\hat{Y}$ = 22.17+0.65X), according to Nunes et al. (2011).

The concentration of stearic acid (C18:0) in the meat did not differ between treatments, although the levels of this in the diet were reduced slightly with the inclusion of palm kernel meal (Table 2). The monounsaturated fatty acid C18:1 cis-9, known for its hypocholesterolemic properties, was present in greater quantities and was not affected by the diet. It is synthesized from stearic acid by the enzyme Δ9-desaturase, which is also involved in the synthesis of CLA (Wood et al., 2008). It is likely that C18:1 cis-9 did not differ since the concentrations of its precursor, C18:0 were also unaffected.

Levels of CLA were not affected by treatment (Table 5). CLA is synthesized in the rumen as an intermediate in the biohydrogenation of linoleic acid (Beaulieu et al., 2002). The concentration of this fatty acid was reduced by the inclusion of palm kernel meal in the diet (Table 2), and therefore a decrease in the levels of CLA in the meat was expected.

However, the increase in NDF intake ($\hat{Y}$ = 616.32+7.51 X), according to Nunes et al. (2011), might have promoted the development of the most important organism in the synthesis of CLA (Khanal and Olson, 2004; Khanal, 2004), the bacterium *Butyrivibrio fibrosolvens*, which is fibrolytic. It is possible that for this reason, despite having less of the precursor fatty acid, CLA levels were not reduced.It is well known that CLA has anticarcinogenic properties, and may reduce the development of adipose tissue in the body, besides acting in the prevention of cardiovascular disease and diabetes (Blankson et al., 2000).

In this study, the n6:n3 ratio did not differ between treatments and all average values were below the maximum recommended value and were lower than those reported by Costa et al. (2009), who also worked with Santa Inês lambs. The n6:n3 ratio is an important indicator of the nutritional quality of meat, as it influences risk factors related to the development of cancer, heart disease and the formation of thrombi or clots that can lead to heart attack (Banskalieva et al., 2000; Enser et al., 2001). Therefore, it is recommended that this ratio is less than 4 (Wood et al., 2003).

The atherogenicity index (AI) increased with the addition of palm kernel meal in the diet and reflects the increased levels of C12:0, C14:0 and C16:0 in the flesh. These saturated fatty acids have a large influence on plasma levels of LDL and HDL (Chardigny et al., 2008) and therefore the lower the value of this index, the more beneficial the product is to human health. The values found in this study were higher than those reported by Costa et al. (2009).

In relation to chain length, the inclusion of palm kernel meal reduced the average length of the fatty acid chains, due to an increase in medium-chain fatty acids and a reduction in long-chain fatty acids. Medium-, short- and branched-chain fatty acids are related to the “sheep smell” that is characteristic of the species (Priolo et al., 2001), but this attribute (smell) received good scores in the sensory evaluation (Table 3).

CONCLUSIONS

Palm kernel meal is an alternative low cost energy food for lambs, especially in northeast Brazil where it is abundant, and can be added to the diet of Santa Inês sheep at a rate of up to 19.5% without causing significant changes in the sensory characteristics of the meat. Nevertheless, its addition altered the fatty acid profile of the meat.

REFERENCES

Andrade, M. B., F. A. F. Macedo, C. C. Jobim, L. Lombardi, F. G. Macedo and E. Gasparino. 2009. Components of live weight, carcass and meat caracteristics of lambs fed with diets containing corn grain silage. Acta. Sci. Anim. Sci. 31(2):183-189.

Anualpec. 2006. Anuário da Pecuária Brasileira. 1th edn. São Paulo.

AOAC. 1990. Official methods of analysis. 12th edn. Association of Official Analytical Chemists, Arlington, Virginia.

Banskalieva, V., T. Sahlu and A. L. Goetsch. 2000. Fatty acid composition of goat muscles and fat depots - a review. Small Rumin. Res. 37:255-268.

Batista, A. S. M., R. G. Costa, D. S. Garruti, M. S. Madruga, R. C. R. E.Queiroga and J. T. Araújo Filho. 2010. Effect of energy concentration in the diets on sensorial and chemical parameters of Morada Nova, Santa Inez and Santa Inez×Dorper lamb meat. Rev. Bras. Zootecn. 39(9):2017-2023.

Beaulieu, A. D., J. K. Drackley and N. R. Merchen. 2002. Concentrations of conjugated linoleic acid (cis-9, trans-11 octadienoic acid) are not increased in tissue lipids of cattle fed with high concentrate diet supplemented with soybean oil. J. Anim. Sci. 80(3):847-861.

Beriain, M. J., A. Horcada, A. Purroy, G. Lizaso, J. Chasco and J. A. Mendizabal. 2000. Characteristics of Lacha and Rasa Aragonesa lambs slaughtered at three live weights. J. Anim. Sci. 78:3070-3077.

Blankson, H., J. A. Stakkestad, H. Fagertun, E. Thom, J. Wadstein and O. Gudmundsen. 2000. Conjugated linoleic acid reduces body fat mass in overweight and obese humans. J. Nutr. 130:2943-2948.

Bonacina, M. S., M. T. M. Osório, J. C. S. Osório, G. F. Corrêia and J. H. Hashimoto. 2011. The influence of sex and finishing system on carcass and meat quality of Texel×Corriedale lambs. Rev. Bras. Zootecn. 40(6):1242-1249.

Bressan, M. C., O. V. Prado, J. R. O. Pérez, A. L. S. C. Lemos and S. Bonagurio. 2001. Effect of the slaughter weight on the physical-chemical characteristic of bergamácia and santa inês lambs meat. Ciênc. e Tecnol. Aliment. 21(3):293-303.

Carvalho, G. G. P., A. J. V. Pires, F. F. Silva, C. M. Veloso, R. R. Silva, H. G. O. Silva, P. Bonomo and S. S.Mendonça. 2004. Ingestive behavior of dairy goats fed on cocoa meal or palm cake. Pesq. Agropec. Bras. 39(9):919-925.

Chardigny, J. M., F. Destaillats, C. Malpuech-Brugère, J. Moulin, E. D. Bauman, A. L. Lock, D. M. Barbano, R. P. Mensink, J. B. Bezelques, P. Chaumont, N. Combe, I. Cristiani, F. Joffre, J. B. German, F. Dionise, Y. Boirie and J. L. Sébédio. 2008. Do *trans* fatty acids from industrially produced sources and from natural sources have the same effect on cardiovascular disease risk factors in healthy subjects? Results of the *trans* Fatty Acids Collaboration study. Am. J. Clin. Nutr. 87:558-566.

Colomer-Rocher, F., P. Morand-Fehr and A. H. Kirton. 1987. Standard methods and procedures for goat carcass evaluation, jointing and tissue separation. Livest. Prod. Sci. 17:149-159.

Costa, R. G., A. S. M. Batista, P. S. Azevedo, R. C. R. E. Queiroga, M. S. Madruga and J. T. Araújo Filho. 2009. Lipid profile of lamb meat from different genotypes submitted to diets with different energy levels. Rev. Bras. Zootecn. 38(3):532-538.

Costa, R. G., F. Q. Cartaxo, N. M. Santos and R. C. R. E. Queiroga. 2008. Goat and sheep meat: fatty acids composition and sensorial characteristics. Rev. Bras. Saúde Prod. An. 9(3):497-506.

Díaz, M. T., I. Álvarez, J. De La Fuente, C. Sañudo, M. M. Campo, M. A. Oliver, M. Fonte i Furnols, F. Montossi, R. San Julián, G. R. Nute and V. Cañeque. 2005. Fatty acid composition of meat from typical lamb production systems of Spain, United Kingdom, Germany and Uruguay. Meat Sci. 71:256-263.

Enser, M., N. Scollan and S. Gulati. 2001. The effects of ruminally-protected dietary lipid on the lipid composition and quality of beef muscle. In: Proceedings Of The 47th International Congress Of Meat Science And Technology, 47, Krakow.

Fernandes, A. R. M., A. A. M. Sampaio, W. Henrique, R. R. Tullio, E. A. Oliveira and T. M. Silva. 2009. Chemical traits and fatty acids composition of beef from young bulls, steers and heifers fed corn silage and concentrate or sugarcane and concentrate with sunflower grains. Rev. Bras. Zootecn. 38(4):705-712.

Ferrão, S. P. B., M. C. Bressan, R. P. Oliveira, J. R. O. Pérez, E. C. Rodrigues and D. A. Nogueira. 2009. Sensory characteristics of meat of Santa Inês lamb submitted to different diets. Ciênc. Agrotec. 33(1):185-190.

Gallo, S. B., E. R. Siqueira and G. T. Rosa. 2007. Effect the sheep and lamb nutrition on the of *Triceps brachii* muscle fatty acid profile of the lambs. Rev. Bras. Zootecn. 36(6):2069-2073.

Geay, Y., D. Bauchart, J. F. Hocquette and J. Culioli. 2001. Effect of nutritional factors on biochemical, structural and metabolic characteristics of muscles in ruminants, consequences on dietetic value and sensorial qualities of meat. Reprod. Nutr. Dev. 41:1-26.

Hara, A. and N. S. Radin. 1978. Lipid extraction of tissues with low-toxicity solvent. Anal. Biochem. 90:420-426.

Johnson, D. D. and C. H. MCGowan. 1998. Diet management effects on carcass attributes and meat quality of young goats. Small Rumin. Res. 28(3):93-98.

Khanal, R. C. and K. C. Olson. 2004. Factors affecting conjugated linoleic acid (CLA) content in milk, meat and egg: a review. Pak. J. Nutr. 3:82-98.

Khanal, R. C. 2004. Potential health benefits of conjugated linoleic acid (CLA): A Review. Asian-Aust. J. Anim. Sci. 17 (9):1315-1328.

Kesava Rao, V., B. N. Kowale and A. K. Verma. 2003. Effect of feeding water washed neem seed kernel cake on the quality, lipid profile and fatty acid composition of goat meat. Small Rumin. Res. 47(3):213-219.

Lanza, M., A. Priolo, L. Biondi, M. Bella and H. Ben Salem. 2001. Replacement of cereal grains by orange pulp and carob pulp in faba bean-based diets fed to lambs: effects on growth performance and meat quality. Anim. Res. 50:21-30.

Licitra, G., T. M. Hernandez and P. J. Van Soest. 1996. Standardization of procedures for nitrogen fractionation of ruminant feeds. Anim. Feed Sci. Technol. 57(11):347-358.

Madruga, M. S., M. S. Galvão, R. G. Costa, S. E. S. Beltrão, N. M. Santos, F. M. Carvalho and V. D. Viaro. 2008. Aroma profile and chemical quality of goat Saanen meat fed with different levels of concentrate. Rev. Bras. Zootecn. 37(5):936-943.

Madruga, M. S., W. H. Sousa, M. D. Rosales, M. G. G. Cunha and J. F. Ramos. 2005. Quality of Santa Inês lamb meat terminated with different diet. Rev. Bras. Zootecn. 34(1):309-315.

Mertens, D. R. 1997. Creating a system for meeting the fiber requirements of dairy cows. J. Dairy Sci. 80(7):1463-1481.

Minim, V. P. R. 2006. Análise sensorial: estudos com consumidores. Viçosa.

National Research Council. 1985. Nutrient requirements of sheep. 6th Ed. Washington, DC.

Nunes, A. S., R. L. Oliveira, M. S. Borja, A. R. Bagaldo, F. M. Macome, I. B. Jesus, T. M. Silva, L. P. Barbosa and A. F. Garcez Neto. 2011. Intake, digestibility and blood parameters of lambs fed diets with palm kernel. Arch. Zootec. (In press).

Perez, J. R. O., M. C. Bressan, N. Bragagnolo, O. V. Prado and A. L. C. Lemos. 2002. Effects of different lamb breeds and their slaughter weights on cholersterol, fatty acids and proximate composition. Ciênc. Tecnol. Aliment. 22(1):11-18.

Pinheiro, R. S. B., A. G. Silva Sobrinho, H. B. A. Souza and S. M. Yamamoto. 2008. Sensorial meat characteristics of non castrated lambs, ewes and wethers. Rev. Bras. Saúde Prod. An. 9(4):787-794.

Priolo, A., D. Micol and J. Agabriel. 2001. Effects of grass feeding systems on ruminant meat colour and flavor: a review. Anim. Res. 50:185-200.

Priolo, A., D. Micol, J. Agabriel, S. Prache and E. Dransfield. 2002. Effect of grass or concentrate feeding systems on lamb carcass and meat quality. Meat Sci. 62:179-185.

Rhee, K. S., D. F. Waldron, Y. A. Ziprin and K. C. Rhee. 2000. Fatty acid composition of goat diets vs. intramuscular fat. Meat Sci. 54:313-318.

Rodríguez-Ruiz, J., E. Belarbi, J. L. G. Sánchez and D. L. Alonso. 1998. Rapid simultaneous lipid extraction and transesterification for fatty acid analyses. Biotechnol. Tech. 12(9):689-691.

Safari, E., N. M. Fogarty, G. R. Ferrier, L. D. Hopkins and A. Gilmour. 2001. Diverse lamb genotypes: Eating quality and the relationship between its objective measurement and sensory assessment. Meat Sci. 57:153-159.

Sañudo, C. A. 2008. Carcass and meat lamb and kid quality and development of consumer acceptability. Rev. Bras. Zootecn. 37(Suppl.):143-160.

Silva Sobrinho, A. G. and A. M. A. Silva. 2000. Produção de carne ovina. Rev. Nac. Carne. 285:32-44.

Silva, H. G. O., A. J. V. Pires, F. F. Silva, C. M. Veloso, G. G. P. Carvalho, A. S. Cezário and C. C. Santos. 2005. Apparent digestibility of diets containing cocoa meal and palm kernel cake in lactating goats. Pesq. Agropec. Bras. 40(4):405-411.

Silva, H. G. O., A. J. V. Pires, P. A. Cunha Neto, G. G. P. Carvalho, C. M. Veloso and F. F. Silva. 2007. Digestibility of nutrients in diets containing ammoniated elephant grass and cocoa meal or palm kernel cake fed to sheep. Rev. Bras. Zootecn. 36(2):499-506.

Siqueira, E. R., R. O. Roça, S. Fernandes and A. Uemi. 2002. Meat sensorial traits from hampshire down, Santa Inês and Bergamácia×Corriedale Lambs, slaughtered at four weights. Rev. Bras. Zootecn. 31(3):1269-1272.

Ulbricht, T. L. V. and D. A. T. Southgate. 1991. Coronary heart disease: seven dietary factors. The Lancet 338(8773):985-992.

Van Soest, P. J., J. B. Robertson and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74(10):3583-3597.

Van Soest, P. J. 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. J. Assoc. Office Anat. Chem. p. 46:829.

Webb, E. C., N. H. Casey and L. Simela. 2005. Goat meat quality. Small Rumin. Res. 60:153-166.

Weiss, W. 1999. Energy prediction equations for ruminant. 1999. In: Cornell Nutrition Conference for Feed Manufacturers, 61. Ithaca. Proceedings Cornell University. Ithaca. pp. 176-185.

Wood, J. D., R. I. Richardson, G. R. Nute, A. V. Fish, 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.

Wood, J. D., M. Enser, A. V. Fisher, G. R. Nute, P. R. Sheard, R. I. Richerdson, S. S. Hughes and F. M. Whittington. 2008. Fat deposition, fatty acid composition and meat quality: a review. Meat Sci. 78:343-358.

Zapata, J. F. F., L. M. J. Seabra, C. M. Nogueira, L. M. J. Seabra, N. N. Barros and A. S. Borges. 2000. Study on lamb quality from northeast Brazil - Physical and sensory properties. Ciênc. Tecnol. Aliment. 20(2):274-277.