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Effect of energy concentration in the diets on sensorial and chemical parameters of Morada Nova, Santa Inez and Santa Inez × Dorper lamb meat

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ABSTRACT - The objective of this study was to investigate the influence of genotype and the energy concentration in the diet on the sensorial and chemical quality of lamb meat. It was evaluated samples from 18 Morada Nova animals, 18 Santa Inez animals, and 18 Santa Inez × Dorper crossbred animals, totalizing 54 animals. The animals were kept with two diets, with energy concentrations of 10.46 and 12.56 MJ ME/kg, respectively, and slaughtered at 30 kg average weight. It was determined contents of protein, moisture, fat and ash, as well as cooking loss, water-holding capacity, shear force, and sensorial attributes of flavour, firmness and juiciness of the meat. Genotype influenced the chemical composition of lamb meat because animals of Morada Nova breed presented the highest moisture content, and Santa Inez × Dorper crossbred showed the highest protein percentage; however, there was no variation in the sensorial attributes of lamb meat of these three genotypes. The diet with the highest energy concentration provides meat with higher juiciness.

Key Words: flavour, juiciness, tenderness

Efeito da concentração de energia da dieta nos parâmetros sensoriais e químicos de carne de cordeiros Morada Nova, Santa Inês e Santa Inês × Dorper

RESUMO - Objetivou-se investigar a influência do genótipo e da concentração energética da dieta na qualidade química e sensorial da carne ovina. Foram avaliadas amostras provenientes de 18 animais Morada Nova, 18 Santa Inês e 18 mestiços Santa Inês × Dorper, num total de 54 animais. Os animais foram mantidos com duas dietas com concentrações energéticas de 10.46 e 12.56 MJ ME/kg e abatidos ao atingirem o peso médio de 30 kg. Foram determinados os teores de proteína, umidade, gordura e cinzas, a perda de peso por cocção, a capacidade de retenção de água, a força de cisalhamento e os atributos sensoriais sabor, dureza e suculência dessas carnes. O genótipo influenciou a composição química da carne ovina, uma vez que os animais da raça Morada Nova apresentaram o maior teor de umidade e os mestiços, o maior percentual de proteína, entretanto não houve variação nos atributos sensoriais da carne ovina desses três genótipos. A dieta com maior concentração energética proporcionou carne com maior suculência.

Palavras-chave: maciez, sabor, suculência

Introduction

Nowadays, consumers are much more aware of the relationship between diet and health, seeking for higher quality food to consume. The past decades were characterized by changes in the trend of consumers regarding the consumption of meat, since it is a source of fat in the human diet, especially saturated fatty acids, which are associated with coronary diseases (Wood et al., 2004).

According to Warriss (2000), when quality of meat is concerned, functional quality is frequently highlighted, regarding the desirable attributes such as yield, technological properties and palatability. Although preferences of consumers for this product are difficult to define, its sensory characteristics are important in the characterization of meat and its by-products (Bukala & Kedzior, 2001).

Thompson (2002) argues that meat is a complex product and, therefore, the assess of its chemical, physical and

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sensory quality is not always easy. Although instrumental methods have advantages such as objectivity and low cost, they only offer incomplete explanations for the complex set of interactions that occur when the product is perceived by the sense organs before and during ingestion. Moreover, according to the same author, juiciness assessments are difficult to obtain through instrumental measurements.

The growing importance of the lamb meat quality perceived by the consumers has been the subject of several studies in recent years on the influence of several factors such as breed, slaughter weight, sex and diet (Hoffman et al., 2003; Sañudo et al., 2000). In Brazil, however, there are only few studies aimed at determining the optimal levels of nutrients required by the genotypes and their possible effect on the characteristics of carcass and meat. Energy, in particular, has received special attention due to its fundamental importance for the functioning of vital organs and processes. According to Mahgoub et al. (2000), energy supplementation improves growth efficiency. However, because researches have been more focused in exotic breeds, there is a lack of additional information on native breeds (Alves et al., 2003).

In this context, the objective of this study was to investigate the chemical and sensory quality of lamb meat from native genotypes - Morada Nova and Santa Inez, and Santa Inez x Dorper crossbred – raised in the semi-arid region of Northeastern Brazil, when submitted to diets with two energy concentrations.

Material and Methods

It was evaluated samples of 54 animals (males), with 18 animals from each of the following native genotypes: Morada Nova and Santa Inez breeds and Santa Inez × Dorper crossbred. The animals were selected based on their weight, purchased from local breeders at an average weight of 15 kg and at approximate 100 days of age, except for representatives of the Morada Nova breed, which were obtained at 150 days of age.

After a 14-day adaptation period, the animals divided into two groups were submitted to the experimental diets, which differed in relation to the energy level, one with 10.46 MJ/kg dry matter (DM) and another with higher energy concentration, 12.56 MJ /kg DM, in order to provide the maximal potential for growth of animals with a weight gain of 250 g /animal /day, and offered without restriction. The diets were based on recommendations from National Research Council (1985) based on soybean meal, corn meal, urea, mineral salt and enriched palm meal which was obtained using fermentation process and action of microorganisms in the presence of a mineral mix (Table 1).

The average confinement period of these animals ranged from 55 days for Santa Inez to 65 days for Morada Nova breeds, being slaughtered at about 30 kg of weight. The experimental diets had promoted an increase of 0.18 and 0.21 kg daily weight gain for the animals with 10.46 and 12.56 MJ/kg DM, respectively.

Before slaughter, animals were submitted to a solid fasting and hydric diet for 16 hours, discount operations followed the recommended procedures by official regulations, with humanitarian slaughter (mechanical desensitization).

After slaughter, the carcasses were cooled for 24 h at 4°C in a cooling chamber. Later, M. *longissimus thoracis* was obtained from the 6^{th} to 10^{th} rib, which were wrapped in vacuous then, in aluminum paper, identified and frozen at -18°C until analysis, with maximal period of 40 days for the beginning of the analysis.

Moisture, ash and protein contents were determined with three repetitions and means calculated according to methodology described in items 985.41, 928.08 and 920.153 respectively (AOAC, 2000).

Total lipids were measured according to methodology described by Folch et al. (1957), with three repetitions and means calculated by submitting the sample to extraction with a mixture of chloroform and methanol (2:1), followed by evaporation of the solvent in an oven at 105°C.

According to procedure mentioned by Duckett et al. (1998a) weight is reduced because of the cooking loss. The samples, composed of three slices of approximately 1.5 cm of thickness, 3.0 cm of length and 2.5 cm of width were weighted, distributed in container covered with aluminum foil and roasted in an oven pre-warmed at 170°C, until

Table 1 - Composition of diets used for lambs

Ingredient (%)	Diet (MJ ME/kg DM)	
	10.46	12.56
Corn meal	25	50.5
Soybean meal	10	15
Enriched palm meal	33	14
Tifton hay	30.5	19
Urea	1	1
Mineral salt	0.5	0.5
Chemical composition (%)		
Dry matter	90.9	90.4
Mineral matter	14.5	13.2
Crude protein	18.6	19.6
Neutral detergent fiber	41.7	33.6
Acid detergent fiber	19.6	13.7
Total digestible nutrients	69.4	81.7
Ether extract	2.3	2.9

temperature of geometric center reached 7°C. Temperature was checked using a copper/constantan thermometer, equipped with digital reader (Delta OHM, I model HD9218, Italy). Then, the samples were transferred from the cold chamber to room temperature and again weighted. Losses during cooking were calculated by the difference of weight of the samples before and after being submitted to thermal treatment and expressed in percentage (g/100g).

Texture was evaluated by the Warner-Bratzler shear force (SF) following methodology described by Duckett et al. (1998b). The samples used were the same as those used for weighting loss due to cooking (WLC), by removing two cylinders from each slice of meat, towards fiber, with the aid of a cutting device of 1.6 cm in diameter. The cylinders were cut transversely using a TA-XT2 texture analyzer (Stabile Micro System Surrey, England), equipped with a Warner Bratzler blade type, with approximately 1 mm of thickness and a rift in triangle form in its base, test operating at 200 mm/min. Maximal shearing force was recorded, and the result expressed in N.

For the sensory evaluation of the lamb meat, the most important attributes to describe the quality of the cooked meat were selected: firmness, juiciness and flavour. The sensory tests were performed by a team of eight trained appraisers composed of five men and three women, with four individuals at ages from 20 to 30 years old, three from 31 to 40 years old and one older than 41 years old. The team was previously selected and trained according to methodology described by Stone et al. (1974), who, during the training, developed a glossary of descriptive terms (Table 2) and evaluation form. The intensity of each attribute was evaluated on a nine-centimeter non-structured scale, anchored at the extremities with terms that express intensity (very and little), in three repetitions.

The calibration of the electric grill used in the preparation of samples was previously performed using a digital thermometer M HD 9218 (Delta OHM, Caselle di Selvazzano, Italy) until the temperature in the geometric center of one of the meat samples was 7°C, which took eight minutes, on average. For the evaluation of samples, the meat was cut into cubes of approximately 2.0 cm in side and submitted to cooking according to calibration, being then wrapped in aluminum paper and stored in a heater in order to keep the temperature up to the sensory evaluation. There was no addition of salt or seasonings.

Each appraiser received two cubes of cooked meat in glass beakers tagged with random numbers of three digits, followed by balancing of the position of samples proposed by Macfie et al. (1989). The tests were carried out in individual cabins under controlled temperature and lighting conditions provided with equipment for the maintenance of the individual temperature of the cooked lamb meat samples at 50ºC until the time of evaluation (Stone et al., 1974). The evaluation form was delivered along with the meat samples.

The experimental design used in this study was a complete random experimental design, in 3 × 2 factorial, testing three genotypes (Morada Nova, Santa Inez and Dorper × Santa Inez), and two diets (10.46 MJ MS/MS kg and 12.56 MJ ME/kg DM). The data were submitted to the analysis of variance with a model including the factors genotype, diet and their interaction. The averages of the chemical composition were compared through the Tukey test at 5%, while for the sensorial analysis the averages were by the Ryan-Einot-Gabriel-Welsch test at 5% and the Pearson correlation between all variables evaluated was also performed, using the statistical package SAS (1996).

Results and Discussion

It could be observed that the native Morada Nova genotype presented the highest moisture content, and the Dorper × Santa Inez crossbred showed the lowest value, with opposite behavior observed for the protein content ($P<0.05$). While the genotype had no influence on the fat and ash percentage (Table 3), there was still no interaction between genotype and diet.

Table 2 - Glossary of sensory attributes with the respective sample-references

Atribute	Definition	Sample-references	
		Few	Much
Firmmess	Necessary strength to compress a piece of meat between molar teeth evaluated at th first bite	Bovine tenderloin	Bovine chest
Juiciness	Perception of the amount of liquid released from the sample after the 5th mastication	Bovine round beef	Bovine tenderloin
Flavour	Characteristic flavour of lamb meat	-	-

Likewise, the influence of the diet also had an effect on moisture and protein content and no effect on fat and ash contents. Lambs fed the diet with low energy concentration had the highest concentration of moisture and protein on the meat. There was no interaction between genotype and diet for the evaluated variables.

The chemical composition values of meat can vary with the animal completion status, resulting in reductions on the protein and water percentages, and increases on the fat levels. Thus, with the increased weight of slaughter, there is a tendency to increase the fat content and to reduce the water content in meat (Bressan et al., 2001; Souza et al., 2004). Since the animals of this experiment were slaughtered at a young age, there was no time for this increase on the fat content.

Fat can change some meat characteristics, mainly in function of its total quantity and distribution in the carcass (Astiz, 2008; Almeida Jr. et al., 2004). Sañudo et al. (2000) report that the muscle/fat proportion can be decisive in the purchase of a meat, since the fat content is associated with soft meat. In the analyzed meats, low fat tenors were verified, probably because they were young animals and due to time of confinement to which they were submitted until they reached the certain weight for slaughter. It was not verified difference ($P<0.05$) for the attributes flavor and hardness (Table 4).

Meat texture determined by the instrumental measuring of the shear force did not differ significantly among the investigated genotypes (Table 4). However, when assessing diet effect, it was observed that the diet with the highest energy concentration provided more tender meat, with difference among the averages of 3.9 N ($P<0.05$). This fact is possibly due to the fattening state and to characteristics such as solubility of proteins present in meat, being influenced by pH, temperature and the beginning of the *rigor mortis* period. Meats analyzed in this study presented low fat contents, and no difference was observed ($P<0.05$) for the flavour and firmness attributes.

The average scores given by appraisers for each sensory attribute evaluated, on a scale from 0 to 9 cm, in which the closer to zero, the less intense is the characteristic evaluated, were the following: firmness ranged from 1.9 to 2.3; juiciness from 3.5 to 4.5, and flavour from 4.5 to 5.0. It was possible to classify the meat as very soft, with intermediate juiciness and flavour. The breed factor did not influence the quality of meat, while the diet interfered in the attribute juiciness, with that containing the highest energy concentration favoring the obtaining of a more juiciness meat ($P<0.05$).

Table 3 - Chemical composition (%) the meat of lambs Morada Nova, Santa Inez and Dorper × Santa Inez (½D + ½SI) submitted to two diets

Source	Composition (%)			
	Moisture	Protein	Fat total	Ash
Genotypes				
Morada Nova	74.7 (±0.40)a	22.6 (±0.45)b	2.2 (±0.35)	0.9 (±0.04)
Santa Inez	74.4 (±0.46)ab	22.9 (±0.46)ab	2.2 (±0.27)	1.0 (±0.05)
DxSI	73.9 (±0.42)b	23.3 (±0.41)a	2.1 (±0.19)	1.0 (±0.03)
Diets (MJ ME/kg DM)				
10.46	74.4 (±0.64)a	23.0 (±0.31)a	2.1 (±0.28)	0.9 (±0.05)
12.56	74.3 (±0.60)b	22.9 (±0.16)b	2.4 (±0.26)	1.0 (±0.03)

Averages followed by different letters in column are different from each other ($P<0.05$).

Table 4 - Sensorial attributes and Shear Force of meat of lambs Morada Nova, Santa Inez and Dorper × Santa Inez (½D + ½SI), submitted to two diets

Sources	Attribute			
	Firmness	Flavour	Juiciness	Shear Force (N)
Genotypes				
Morada Nova	2.7 (± 2.00)	4.5 (± 1.60)	3.7 (± 2.40)	34.5 (± 2.39)
Santa Inez	2.5 (± 1.80)	4.5 (± 1.70)	3.7 (± 2.30)	33.3 (± 1.54)
Dorper × Santa Inez	2.6 (± 1.10)	4.3 (± 1.50)	3.7 (± 2.20)	33.9 (± 1.39)
Diet (MJ ME / kg DM)				
10.46	2.4 (± 1.50)	4.5 (± 1.60)	3.3 (± 2.10)b	27.1 (± 2.18)
12.56	2.7 (± 1.87)	4.4 (± 1.67)	4.0 (± 2.41)a	31.0 (± 1.37)

Averages with same letter in the same column. in each effect, are not different from each other at the significance level of 5%.

Through the obtained data, it could be inferred that, regarded to the fat content uniformity, no variations (P<0.05) for the flavour attribute were observed. However, the difference found for the juiciness characteristic could be attributed to different moisture and protein contents present in samples, provided by the diet with the highest energy concentration (Table 3).

Assessing the attribute flavour, it could be observed homogeneity of scores, with breed and diet factors not interfering on this parameter. Authors such as Costa et al. (2009), Martinez-Cerezo et al. (2005) and Teixeira et al. (2005) assessed the quality of the lamb meat and they found no influence of breed on the attribute flavour.

The effect of the feeding of lambs from different breeds on the meat sensory characteristics indicates that breed only influences the attribute initial juiciness (Hoffman et al., 2003). Since this attribute is related to the ability of the muscle to release its constitutive water and infiltrate lipid content, it could be inferred that there was a possible genetic influence, since the animals were submitted to the same diet. Because animals received different diets in this work, the effect of the nutrition on the meat juiciness was evidenced.

Sensory evaluations on meat of Corriedale, Pampinta breeds and theirs crossings carried out by Suarez et al. (2000), indicated that, in general, the softness score was greater than those achieved by other attributes; however, no differences in relation to any of these sensory measures between genotypes were verified. In general, these lamb meat samples were characterized by a slightly intense flavour, softness and juiciness, corroborating with the profile of the meat studied here, which showed low firmness and intermediate juiciness and flavour.

In relation to the influence of diet on the sensory quality of the lamb meat, several studies have been conducted and similar to the results found in this research, there was an interference of the diet on the sensory attributes (Ådnøv et al., 2005; Tonetto et al., 2004; Ponnampalam et al., 2002). Authors such as Hopkins et al. (2001) and Myhara et al. (2000) did not observe any interference of diet on the sensory parameters, as observed in this test, except for the attribute juiciness, which was similar to the findings of this work. Juiciness may suffer influence from the concentrate level offered to the animal due to changes occurred in the fatty acids composition, leading to a fat softnen (Siqueira et al., 2002).

Meat from lambs finished in confinement is more tender and juicer than that from lambs raised on pasture, possibly due to the variations found in the fat content among carcasses (Priolo et al., 2002; Fischer et al., 2000), unlike the result of this experiment, in which the assessed genotypes presented similar values for the fat content (Table 3), and for the attribute firmness, whose means ranged from 2.5 to 2.7 on a scale where the proximity to zero indicates lower firmness (Table 4), with no influence from the factor diet for both parameters.

To assess the association level between the chemical composition and the sensory attributes of meat from Morada Nova, Santa Inez and Dorper × Santa Inez genotypes submitted to diets with different energy concentrations, the Pearson correlation analysis was performed considering all information, regardless the variation sources (Table 5).

The amount of intramuscular fat can affect meat sensory properties through the replacement of the muscle fiber, which is firm, by soft fat. According to Sañudo et al. (2000), this makes the meat more tender and juicy, although did not it was not observed any difference in relation to the odor intensity, juiciness and flavour quality, supporting the idea that a minimum of fat is required to produce detectable palatability changes.

Intensity of flavor increases with the fat level, when meat from lambs with different carcass weights are compared, according to Sañudo et al. (1996). Although the quality of this product improves significantly as fat

Table 5 - Correlation of Pearson (r) among chemical composition, physical and sensorial characteristics of meat of lambs Morada Nova, Santa Inez and Dorper × Santa Inez

Source	Protein		Fat total	cooking loss	Water-holding capacity	Shear force	Firmness	Flavour	Juiciness
Moisture	-0.681***	-0.167	-0.187	-0.129	0.092	0.091	-0.200	-0.167	0.041
Protein	-	-0.482***	0.190	0.124	-0.166	0.122	0.213	0.180	-0.002
Fat total		-	-0.104	0.036	0.129	-0.273*	-0.014	-0.231	-0.184
Ash			-	-0.159	-0.014	0.117	0.032	-0.058	-0.020
cooking loss				-	-0.196	0.196	-0.129	0.177	0.170
Water-holding capacity					-	-0.035	-0.072	-0.232	-0.174
Shear force						-	0.014	0.155	0.241
Juiciness							-	-0.106	-0.283*
Flavour								-	0.377**

* (P<0.05), ** (P<0.01), *** (P<0.001)

content increases, only very thin animals are adversely affected because they present a less pronounced flavour.

The attribute firmness was negatively correlated with juiciness (r = –0.283) and flavour (r = –0.106), indicating that less hard meats were perceived by appraisers as being juicer and tastier because they present higher flavour intensity. The direct relationship between flavour and juiciness was confirmed by the significant positive correlation (r = 0.377) between these two variables.

Observing the association between protein and moisture, a negative correlation (r = –0.681) is observed, without affecting the meat quality, however. The negative correlation between protein and fat (r = –0.482) also shows that the diet offered to the animals, considering that animals were slaughtered at early ages, was rather aimed at the formation of tissues and not at the fat deposition.

Conclusions

Genotype does not influence in the sensory attributes of the lamb meat, and the consumer can choose any of the native breeds without any harm on the organoleptic characteristics. The diet with lower energy concentration provides more juiciness meat, showing that the nutritional manipulation can provide a product with differentiated sensory quality.

References

ÅDNØV, T.; HAUG, A.; SBRHEIN, O. et al. Grazing on mountain pasture - does is affect meat quality in lambs? **Livestock Production Science**, v.94, p.25-31, 2005.

ALMEIDA JR., G.A.; COSTA, C.; MONTEIRO, A.L.G. et al. Meat quality of lambs fed with high moisture corn silage in creep feeding. **Revista Brasileira de Zootecnia**, v.33, n.4, p.1039-1047, 2004.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS - AOAC. 17.ed. **Official methods of analysis**. Washington, DC: AOAC, 2000.

ASTIZ, C.S. Carcass and meat lamb and kid quality and development of consumer acceptability. **Revista Brasileira de Zootecnia**, v.37, p.143-160, 2008 (supl. especial).

ALVES, K.S.; CARVALHO, F.F.R.; FERREIRA, M.A. et al. Níveis de energia em dietas para ovinos Santa Inês: características de carcaça e constituintes corporais. **Revista Brasileira de Zootecnia**, v.32, n.6, p.1927-1936, 2003 (supl.).

BRESSAN, M.C.; PRADO, O.V.; PERÉZ, J.R.O. et al. Efeito do peso ao abate de cordeiros Santa Inês e Bergamácia sobre as características físico-químicas da carne. **Ciência e Tecnologia de Alimentos**, v.21, n.3, p.293-303, 2001.

BUKALA, J.; KEDZIOR, W. Consumer criteria of quality of meat and meat products. In*:* INTERNATIONAL CONGRESS OF MEAT SCIENCE AND TECHNOLOGY. 47., 2001, Kraków, Poland. **Proceedings...** Kraków, Poland, 2001. p.262-263.

COSTA, R.G.; BATISTA, A.S.M.; AZEVEDO, P.S. et al. Lipid profile of lamb meat from different genotypes submitted to diets with different energy levels. **Revista Brasileira de Zootecnia**, v.38, n.3, p.532-538, 2009.

DUCKETT, S.K.; KLEIN, T.A.; DODSON, M.V. et al. Tenderness of normal and callipyge lamb aged fresh or after freezing. **Meat Science**, v.49, n.1, p.19-26, 1998a.

DUCKETT, S.K.; KLEIN, T.A.; LECKIE, R.K. et al. Effect of freezing on calpastatin activity and tenderness of callipyge lamb. **Journal of Animal Science**, v.76, n.7, p.1869-1874, 1998b.

FISHER, A.V.; ENSER, M.; RICHARDSON, R.I. et al. Fatty acid composition and eating quality of lamb types derived from four diverse breed x production systems. **Meat Science**, v.55, n.2, p.141-147, 2000.

FOLCH, J.; LESS, M.; STANLEY, S. A simple method for the isolation and purification of total lipids from animal tissues. **Journal Biological Chemistry**, v.226, n.1, p.497-509, 1957.

HOFFMAN, L.C.; MULLER, M.; CLOETE, S.W.P. et al. Comparison of six crossbred lamb types: sensory, physical and nutritional meat quality characteristics. **Meat Science**, v.65, n.3, p.1265-1274, 2003.

HOPKINS, D.L.; HALL, D.G.; CHANNON, H.A. et al. Meat quality of mixed sex lambs grazing pasture and supplemented with, roughage, oats or oats and sunflower meal. **Meat Science**, v.59, n.3, p.277-283, 2001.

MACFIE, H.J.; BRATCHEL, N.; GREENHOFF, K. et al. Design to balance the effect of order of presentation and first-order carry-over effects in hall tests. **Journal of Sensory Studies**, v.4, n.2, p.129-148, 1989.

MAHGOUB, O.; LU, C.D.; EARLY, R.J. Effects of dietary energy density on feed intake, body weight gain and carcass chemical composition of Omani growing lambs. **Small Ruminant Research**, v.37, n.1, p.35-42, 2000.

MARTÍNEZ-CEREZO, S.; SAÑUDO, C.; MEDEL, I. et al. Breed, slaughter weight and ageing time effects on sensory characteristics of lamb. **Meat Science**, v.69, n.3, p.571-578, 2005.

MILLER, R.; GRONINGER JR., H.S. Functional properties of enzyme-modified acylated fish protein derivatives. **Journal Food science and Technology**, v.41, n.2, p.268-272, 1976.

MYHARA, R.M.; BYERLEY, D.J.; MAHGOUB, O. et al. Effects of testicular status and feeding diets containing date palm by-product on the sensory attributes of Omani lamb meat. **Small Ruminant Research**, v.38, n.1 p.57-61, 2000.

NATIONAL RESEARCH COUNCIL - NRC. **Nutrient requirements of domestic animals**: nutrient requirements of sheep. 6.ed. Washington: National Academy, 1985. 99p.

PONNAMPALAM, E.N.; SINCLAIR, A.J.; EGAN, A.R. et al. Dietary manipulation of muscle long-chain omega-3 and omega-6 fatty acids and sensory properties of lamb meat. **Meat Science**, v.60, n.2 p.125-132, 2002.

PRIOLO, A.; MICOL, D.; AGABRIEL, J. et al. Effect of grass or concentrate feeding systems on lamb carcass and meat quality. **Meat Science**, v.62, n.2 p.179-185, 2002.

SAÑUDO, C.; ALFONSO, M.; SÁNCHEZ, A. et al. Carcass and meat quality in light lambs from different fat classes in the EU carcass classification system. **Meat Science**, v.56, n.1 p.89-94, 2000.

SAÑUDO, C.; SANTOLARIA, M.P.; MARIA, G. et al. Influence of carcass weight on instrumental and sensory lamb meat quality in intensive production systems. **Meat Science**, v.42, n.2 p.195-202, 1996.

SIQUEIRA, E.R.; ROÇA, R.O.; FERNANDES, S. et al. Meat sensorial traits from Hampshire Down, Santa Inez and Bergamácia x Corriedale lambs, slaughtered at four weights. **Revista Brasileira de Zootecnia**, v.31, n.3, p.1269-1272, 2002.

STONE, H.; SIDEL, J.; OLIVER, S. et al. Sensory evaluation by quantitative descriptive analysis. **Food Technology**, v.28, n.11, p.24-34, 1974.

STATISTICAL ANALYSIS SYSTEMS - SAS. **User's guide**: Statistics. Versão 6.12. Cary: Caroline State University, 1996. (CD-ROM).

SOUZA, X.R.; BRESSAN, M.C.; PERÉZ, J.R.O. et al. Efeitos do grupo genético, sexo e peso ao abate sobre as propriedades físico-químicas da carne de cordeiros em crescimento. **Ciência e Tecnologia de Alimentos**, v.24, n.4, p.543-549, 2004.

SUAREZ, V.H.; BUSETTI, M.R.; GARRIZ, C.A. et al. Pre-weaning growth, carcass traits and sensory evaluation of Corriedale, Corriedale × Pampinta and Pampinta lambs. **Small Ruminant Research**, v.36, n.1, p.85-89, 2000.

TEIXEIRA, A.; BATISTA, S.; DELFA, R. et al. Lamb meat quality of two breeds with protected origin designation. Influence of breed, sex and live weight. **Meat Science**, v.71, n.3, p.530-536, 2005.

THOMPSON, J. Managing meat tenderness. **Meat Science**, v.62, n.3, p.295-308, 2002.

TONETTO, C.J.; PIRES, C.C.; MÜLLER, L. et al. Carcass yield, meat physical characteristics and live weight components in lambs finished in three feeding systems**. Revista Brasileira de Zootecnia**, v.33, n.1, p.234-241, 2004.

WARRISS, P.D. **Meat science**. An introduction text. Wallingford: CABI Publishing. CAB International, 2000. 310p.

WOOD, J.D.; RICHARDSON, R.I.; NUTE, G.R. et al. Effects of fatty acids on meat quality: a review. **Meat Science**, v.66, n.1, p.21-32, 2004.