

# Meat quality of Santa Inês and F1 Santa Inês X Dorper Lambs

## Qualidade da carne de cordeiros Santa Inês e Santa Inês F1 X Dorper

Rafael S. Costa, Luciana S. V. Henriques, Felipe R. A. Ferreira do Valle, Jonhny A. Maia Júnior, Éverton N. Alves, Fábio C. Henry\*, Célia R. Quirino e Alexandre C. Santos Júnior

<sup>1</sup>Universidade Estadual do Norte Fluminense Darcy Ribeiro, Laboratório de Tecnologia de Alimentos. Campos dos Goytacazes - CEP: 28.013-602, RJ, Brazil.  
E-mail: \*fabioacosta@uenf.br, author for correspondence

Received/Recebido: 2014.07.18  
Accepted/aceite: 2015.07.10

### RESUMO

Foram selecionados ao acaso 50 cordeiros não castrados (25 da raça Santa Inês e 25 F1 Santa Inês x Dorper) para a avaliação da cronologia dentária, peso vivo ao abate, altura de cernelha e de garupa, comprimento corporal e perímetro torácico. Após a sangria, analisou-se a temperatura e pH em diferentes intervalos de tempo (4h; 12h e 24h) nos músculos *Semitendinosus* e *Triceps brachii* e força de corte em 48h no músculo *Semitendinosus*. Paralelamente, foi realizada a correlação entre a análise sensorial e a análise instrumental desse músculo. A temperatura da câmara fria variou de 12,2°C às 4hs a -0,5°C às 24hs e a temperatura média das carcaças foi de 26,80°C e -0,20°C, respectivamente. O pH médio inicial do músculo *Semitendinosus* foi de 6,62 às 4 hs e o final 5,64 às 24 hs enquanto no músculo *Triceps brachii* foi de 6,50 às 4hs e 5,68 às 24hs. No músculo *Semitendinosus* a força de corte foi semelhante entre cordeiros da raça Santa Inês e F1 Dorper x Santa Inês, demonstrando que o grupo genético não influenciou a tenrura da carne. O painel sensorial confirmou os resultados obtidos na análise instrumental. Na correlação da análise instrumental (força de corte) com a análise sensorial, quando comparados os diferentes grupos genéticos, observou-se uma elevada correlação inversa ( $r = -0,87$ ). Os valores médios para o comprimento corporal e perímetro torácico não apresentaram diferenças significativas entre os grupos genéticos.

**Palavras-chave:** cordeiros, qualidade da carne, medidas morfométricas.

### ABSTRACT

Fifty intact ovine males were randomly selected, 25 of the Santa Inês breed and 25 F1 Santa Inês x Dorper, to evaluate the dental chronology, live weight at slaughter, withers height, hip height, body length and thoracic circumference. After exsanguination, temperature and pH were measured at different times (4h; 12h and 24h) in the *Semitendinosus* and *Triceps brachii* muscles, as well as the shear force (48h) of *Semitendinosus* muscle. In parallel, the correlations between sensory analysis and instrumental analysis values for these muscles were assessed. The mean temperatures of the carcasses were 26.80°C and -0.20°C, respectively. The mean initial pH of *Semitendinosus* was 6.62 (4h) and the final was 5.64 (24h), whereas the initial pH for the *Triceps brachii* was 6.50 (4h) and the final, 5.68 (24h). *Semitendinosus* muscle shear force was similar for lambs of Santa Inês breed and F1 Dorper x Santa Inês breed, demonstrating that the genetic group did not affected meat tenderness. The sensory panel confirmed the instrumental analysis results. When different genetic groups were compared, a high inversed correlation between the instrumental analysis (shear force) and the sensory analysis was obtained ( $r = -0.87$ ). The mean for body length and thoracic circumference levels did not show a significant difference for different genetic groups.

**Keywords:** lambs, meat quality, morphometric measurements.

## Introduction

The breeding of small ruminants is expanding in Brazil to diversify animal production, in order to supply the national and international consumer market. So today Brazil is an importer of sheep meat (Anualpec, 2007). According to the data from the Brazilian Institute of Geography and Statistics – IBGE - (2007), the Brazilian ovine herd has 16 million heads, approximately. Woolless animals are mainly concentrated in the Northeast Region (58%), and the Southeast is the fifth in the ranking with 4% of the ovine herd.

There has been a significant increase in the demand for lamb meat, especially in the major urban areas (França *et al.*, 2006), as the result of changes in consumers' eating habits, searching for quality, palatability, tenderness and lower fat levels (Neres *et al.*, 2001). This fact has contributed to the ovine production expansion (França *et al.*, 2006), providing an increase in the offer of a high quality source of protein (Ribeiro *et al.*, 2001).

Morphometric measurements analysed together with other zootechnical indexes represent an important database for the individual assessment of these animals and for the determination of the production system evolution (Borges *et al.*, 2004).

At slaughter, more precisely after exsanguination, a series of biochemical and structural changes take place in muscle tissue during the first 24-hour period when muscle is converted into meat. In this period of time, many factors can affect the rigor mortis process, thus affecting the final quality of the meat (Aberle *et al.*, 2001). The decrease in both pH and temperature during the carcasses rigor mortis process influence directly the quality of the meat. The rigor mortis speed is mainly controlled by the muscle's glycogen reserve, pH and temperature (Johnson *et al.*, 1989; Koochmaraie *et al.*, 1991; Monteiro *et al.*, 2001). The tenderness and weight loss by cooking are also important parameters in the evaluation of meat quality (Costa *et al.*, 2006). Instrumental analysis (shear force) and sensory analysis are the methodologies used to measure the meat tenderness (Lyon and Lyon, 1997).

The crossing of Dorper and Santa Inês sheep is advantageous, since it generates offspring with a greater potential for weight gain, consequently reducing the time interval until slaughtering, and

a reduction in production costs (Madruga *et al.*, 2006). Lambs are animals that provide, at this stage, the best meat quality and the highest carcass yields, as well as the best production efficiency due to their fast growth (Rosa *et al.*, 2000).

The purposes of this work were: (1) assess the behavior of the rigor mortis process in *Semitendinosus* and *Triceps brachii* muscles of refrigerated carcasses; (2) study the effect of the genetic group on meat tenderness of *Semitendinosus* muscle; (3) correlate the instrumental analysis (shear force) values with sensory analysis; and (4) perform the morphological assessment of Santa Inês and F1 Santa Inês x Dorper ovine breeds

## Materials and methods

Fifty (50) intact male sheep were randomly selected: 25 of Santa Inês breed and 25 F1 Santa Inês x Dorper breed, all with milk teeth (lambs). Body measures were taken before slaughter. To perform the morphometric measurements, a tape with precision of 1 cm and a balance were used. The measures studied included: live weight; wither height; hip height; body length and thoracic circumference (Osório *et al.*, 1998; Santana *et al.*, 2001).

Animals' age was determined by examining their teeth in the ante mortem inspection and confirmed at the slaughter room of slaughterhouse under the State Inspection Service (SIE 504) in Campos dos Goytacazes, Rio de Janeiro State. The stunning procedures were conducted according to the Technical Regulation of Stunning Methods for Humane Slaughter of Animals (RISPOA) (BRAZIL, 1997). The animals were weighed, slaughtered and eviscerated; and the carcasses moved to the chilling room, where temperatures were measured with a thermo hygrometer (average air temperature of 0.8 °C and relative humidity of 81.2%) at 4h, 12h and 24h.

At the same intervals, the half carcasses temperature was taken by introducing the metal rod of a digital thermometer to a depth of 5 cm in the muscle mass close to the ischium. Samples were collected from each carcass, at the same time intervals mentioned above, from the *Semitendinosus* and *Triceps brachii* muscles to determine the pH with a Handylab 1 – Schott pHmeter, using a homogeneous solution of 10 g of sample in 100 ml of distilled water (Brazil, 1999).

Samples of 250 g, approximately, of the *Semitendinosus* muscle of each carcass were taken 24h after the beginning of bleeding. Samples were placed individually in a plastic package, identified and stored in an isothermal box. Subsequently, the samples were weighed, cooked until reached an internal temperature of 75 °C, then cooled at room temperature during 1h, drained and weighed. The percentage of cooking losses was calculated by the difference between the initial and the final weights.

Then, seven cylinders with 1.27 cm diameter and 7.0 cm length were taken and sheared in half using a Texture Analyser (Model 3000, Electronics Manufacturing Company, Manhattan, KS, USA) with a Warner-Bratzler probe to obtain the values of shear force, according to the method proposed by Kerth *et al.* (2003).

The sensory analysis of *Semitendinosus* muscle was performed by a team of six judges selected and trained after an evaluation of their answers to the recruitment questionnaire, distributed among the employees and graduate and postgraduate students of the Darcy Ribeiro North Fluminense State University (UENF), Campos dos Goytacazes, RJ, Brazil. The questionnaire contained a consent form which was signed by the consumer regarding their acceptance to participate voluntarily in the test (Meilgaard *et al.*, 2006). The judge recruitment criteria were as follows: age between 18 and 45 years, liking lamb to a degree equal or above "like moderately," have no history of diseases involving diet restrictions for lamb meat, and also showing

themselves to be interested and morally bound to the research project.

First, the samples were cut in cubes of 3 cm and then they were cooked at 75 °C for one hour. The samples were presented to the judges in individual white-bottom plates, which had been previously coded with random three-digit numbers. The meat from the *Semitendinosus* muscle was served at a temperature of 40-50°C with crackers used for mouth cleaning between tastings.

The judge team recruitment was conducted with six consumers of the product tested and the samples were presented to them on a round table during training. Reference materials that represented the extreme values of tenderness in lamb meat were presented, and the judges were instructed to perceive the tenderness at first bite using their molars (Meilgaard *et al.*, 2006).

After two training sessions with the whole team, the performance test was held. The two samples (meat of Santa Inês lambs and of F1 Santa Inês x Dorper lambs) were presented under laboratory conditions, in individual booths with four replicates per judge. An unstructured hedonic scale of 9 cm with extremes anchored was used to assess meat tenderness.

The trained and selected judge team evaluated the two samples in three replicates in three sessions during the day. The same form used for the performance test was used for tenderness assessment.

**Table 1** - Mean (X) and standard deviation(s) of live weights at slaughter (kg), withers height and hip height (cm), body length (cm) and thoracic circumference (cm).

Variable sources	Santa Inês	F1 Santa Inês x Dorper
	X ± s	X ± s
LWS	24.67 <sup>a</sup> ± 2.97	22.34 <sup>a</sup> ± 2.25
WH	61.65 <sup>a</sup> ± 3.09	51.80 <sup>b</sup> ± 2.07
HH	62.05 <sup>a</sup> ± 3.60	54.87 <sup>b</sup> ± 3.15
BL	57.00 <sup>a</sup> ± 4.82	56.92 <sup>a</sup> ± 3.46
TC	68.75 <sup>a</sup> ± 2.42	68.67 <sup>a</sup> ± 3.52

Where: LWS = live weight at slaughter, WH = withers height, HH = hip height, BL = body length, TC = thoracic circumference.  
\* Averages on the same line followed by different letters vary significantly from each other (P < 0.05) according to Tukey's test.

Statistical analysis regarding each muscles' (Semitendinosus and Triceps brachii) rigor mortis process, behavior of the chilling room temperature measurements, muscles' temperature and pH over time (4h, 12h and 24h after bleeding) was accomplished by analysis of variance for repeated measures with a significance level of 5% (SAS, 2003).

The analysis of variance for a completely randomized design followed by Tukey's test at a significance level of 5% was conducted for the morphometric measurement, shear force and cooking loss data.

The mean scores for tenderness of each sample were correlated with the average values obtained in the instrumental analysis of tenderness, and the Pearson's correlation coefficients were determined (SAS, 2003).

## Results and discussion

The live weights at slaughter were 24.67 kg (Santa Inês) and 22.34 kg (F1 Santa Inês x Dorper) (Table 1).

Statistical analysis revealed no significant difference ( $p > 0.05$ ) for live weight at slaughter (Table 1), a result also found by Araújo Filho *et al.* (2007) when evaluating Morada Nova, Santa Inês breeds and Santa Inês X Dorper crossbred.

Live weights at slaughter varying from 22.76 kg to 25.14 kg were found by Santana *et al.* (2001) for

Santa Inês lambs. While analyzing Santa Inês lambs, Louvandini *et al.* (2007) found live weights at slaughter of 25 kg. However, Sousa *et al.* (2008) found a live weight of 19 kg for Santa Inês lambs from an experimental herd, a value slightly below the ones found in this study using sheep from a commercial herd.

The mean withers heights of Santa Inês and F1 Santa Inês x Dorper were 61.7 cm and 51.8 cm, respectively; and the hip heights of Santa Inês and F1 Santa Inês x Dorper were 62.1 cm and 54.9, respectively. Statistical analysis showed a significant difference ( $p < 0.05$ ) in the values for withers height and hip height between breeds. These results are consistent with those described in a study of racial patterns of genetic groups (Ekiz *et al.*, 2009). The Dorper breed is considered a medium height and the Santa Inês breed

a high height breed. Therefore, the withers heights and the hip heights found were higher for Santa Inês animals. These data were confirmed by the observations made by Araújo Filho *et al.* (2007). Mean values for body length and thoracic circumference did not show significant difference ( $P > 0.05$ ) for the genetic groups studied (Table 1). Similar results were observed by Carneiro *et al.* (2007), and Araújo Filho *et al.* (2007).

The mean values found for pH of *Triceps brachii* and *Semitendinosus* muscles are shown in Table 2. Tukey's test revealed no significant difference ( $p > 0.05$ ) between the mean values of pH in *Triceps brachii* and *Semitendinosus* muscles at all time intervals.

**Table 2** - Mean standard deviation of temperatures (°C) from chilling room and ovine carcasses and pH of *Triceps brachii* (Tb) and *Semitendinosus* (St) muscles at three time intervals post mortem during industrial chilling.

Analysis	Samples	Post mortem time (h)		
		4	12	24
Temperature (°C)	Chilling room	12.2	2.8	-0.5
	Carcass	26.80 <sup>a</sup> ± 1.87	7.20 <sup>b</sup> ± 0.79	-0.20 <sup>c</sup> ± 0.42
pH	(Tb)	6.50 <sup>aA</sup> ± 0.12	5.82 <sup>bA</sup> ± 0.12	5.68 <sup>cA</sup> ± 0.11
	(St)	6.62 <sup>aA</sup> ± 0.10	5.76 <sup>bA</sup> ± 0.09	5.64 <sup>cA</sup> ± 0.06

Averages on the same line (small letters) followed by different letters vary significantly from each other ( $P < 0.05$ ) according to Tukey's test. Averages on the same column (capital letters) followed by different letters vary significantly from each other ( $P < 0.05$ ) according to Tukey's test.

**Table 3** - Mean (X) and standard deviation (s) for shear force (kg) and cooking loss (%) of *Semitendinosus* muscles of ovine carcasses in relation to genetic groups (Santa Inês and F1 Santa Inês x Dorper)

Sample	Shear force (kg)		Cooking loss (%)	
	F1 Santa Inês x		F1 Santa Inês x	
	Santa Inês	Dorper	Santa Inês	Dorper
<i>Semitendinosus</i>	1.45 <sup>a</sup> ± 0.34	1.50 <sup>a</sup> ± 0.59	35.16 <sup>a</sup> ± 1.55	33.75 <sup>a</sup> ± 1.26

Averages on the same line followed by the same letters do not show differences ( $P > 0.05$ ) according to Tukey's Test.

Temperature values of the carcasses were 26.80 °C (4h), 7.20 °C (12h) and -0.20 °C (24h); while the temperatures at the chilling room were 12.2 °C (4h), 2.8 °C (12h) and -0.5°C at 24 hours after bleeding (Table 2). A gradual temperature decrease in the muscles was observed. This decrease allows adequate activity of the proteolytic enzymes without the inconvenience of protein denaturation (sharp fall in early post-mortem pH) or the delay of rigor mortis process due to cold shortening (Hwang *et al.*, 2004). Tornberg *et al.* (2000) reported that chilling room temperatures between 1 °C and 7 °C are ideal for a normal rigor mortis process, conferring meat a better tenderness.

Both Triceps brachii and Semitendinosus muscles showed a linear pH decrease during the 24-hour period post mortem, with an average final pH of 5.68 and 5.64, respectively (Table 2). These results are acceptable since pH values between 5.4 and 5.9 are desirable, because meats with pH values above 6.0, despite having a satisfactory tenderness, are considered unsuitable for commercialization due to reduced shelf life (Devine *et al.*, 1993).

The pH/temperature window was one of the initial specifications for the Meat Standards Australia (MSA). Studies led to the development of the MSA pH/temperature window, whereby electrical inputs during processing were managed to achieve a pH/temperature relationship of higher muscle pH than 6 at temperatures higher than 35 °C, and a pH of less than 6 for muscle temperatures lower than 12 °C (Thompson, 2002).

The final pH of the *Semitendinosus* muscle was 5.64 ± 0.06, a value similar to those reported by Bressan *et al.* (2001), who found 24-hour post mortem pH values from 5.67 to 5.75 in *Semimembranosus* muscle. While analyzing genetic groups of lambs from Ile de France x Santa Inês and Bergamácia x

Santa Inê, Souza *et al.* (2004) found final pH values of 5.70, which are close to those reported in this study. However, Ferrão *et al.* (2009) found pH values, 24 hours post mortem, from 5.53 to 5.57 in *Semimembranosus* muscle, when studying the meat quality of Santa Inês lambs.

The mean shear force and cooking loss values for the *Semitendinosus* muscle of ovine carcasses from the Santa Inês and F1 Santa Inês x Dorper genetic groups are described in Table 3.

There were no differences ( $p > 0.05$ ) in cooking losses and shear force between the two genetic groups. Souza *et al.* (2004) reported that shear force was not affected by genetic group, gender and weight at slaughter in Ile de France x Santa Inês and Bergamácia x Santa Inês genetic groups, when they evaluated the *Semimembranosus* muscle tenderness of these lambs.

The averages obtained for shear force are within the acceptable values proposed by Bickerstaffe *et al.* (1997). According to these authors, lamb that show a shear force above 11 kg is defined as hard and have reduced consumer acceptance. The shear force values in this work can be explained by the linear decline in temperature and pH, which allowed the appropriate activity of proteolytic enzymes resulting in higher meat tenderness.

A wide range of results are observed in the literature, with mean values from 2.5 kg to 15.1 kg (Souza *et al.*, 2004). Zundt *et al.* (2006) observed a 1.64 kg average value of shear force in the *Semitendinosus* muscle of Santa Inês sheep. Frescura *et al.* (2005) reported shear force values of 2.33 kg in the *Semitendinosus* muscle of lambs from crosses of Ile de France x Texel. The results obtained by these authors shown a great resemblance to the ones of the present work. However, higher mean values

were observed by Santello *et al.* (2006) (6.99 kg in the *Semitendinosus*) and by Ferrão *et al.* (2009) (5.59 kg to 6.57 kg in *Semimembranosus*).

Bressan *et al.* (2001) and Dransfield *et al.* (1990) reported that the genetic groups showed no significant difference on cooking losses. Ferrão *et al.* (2009), while assessing the effects of various diets on cooking losses in *Semimembranosus* muscle of Santa Inês breed, found average values of 46.0%, 45.9% and 46.0%. These values were above most of the results described by other authors which is probably due to the fat content and the cooking and cooling temperatures of the samples.

The cooking losses in this work are consistent with Bressan *et al.* (2001), who observed values from 29.9% to 33.1%, as well as with Bonagurio *et al.* (2003) who observed mean values of 36.1% in males and 33.7% in females. Silva Sobrinho *et al.* (2005), while analyzing the cooking losses of lambs' *Semimembranosus* muscle, found values ranging from 38.0% to 38.9%, similar to the values found in this work. The cooking losses average value (19.55%) for *Semitendinosus* muscle of Santa Inês x Dorper animals in the study of Santello *et al.* (2006) was lower than that found in this study, probably due to the younger age of the animals.

The linear correlation coefficient ( $r = -0.87$ ) between the instrumental analysis (shear force) and sensory analysis (perception of meat tenderness during the first bite using the molars) was significant ( $p < 0.05$ ). Similar results have been described for *Longissimus dorsi* and *Triceps brachii* muscles tenderness of Santa Inês lambs and sheep measured at different periods post-mortem (Oliveira *et al.*, 2004), in which a correlation between sensory and instrumental analyses was also observed.

## Conclusion

The decline in the temperature and pH of ovine carcasses occurred within the appropriate standards for the onset of rigor mortis and its resolution.

The shear force of *Semitendinosus* muscle was similar for Santa Inês and F1 Santa Inês x Dorper lambs, indicating that the genetic group did not influenced meat tenderness.

Comparison of instrumental analysis versus sensory analysis showed a significant linear correlation.

The mean values of morphometric measurements, live weight at slaughter, thoracic circumference and body length observer in Santa Inês lambs were similar for F1 Santa Inês X Dorper lambs.

## Acknowledgments

The authors would like to thank the Slaughterhouse Fricampos, Rio de Janeiro, Brazil, for allowing us to conduct this study at their facilities and for supplying us the samples. This research was funded by FAPERJ, Carlos Chagas Filho Foundation for Research Support of the State of Rio de Janeiro.

## References

- Aberle, E. D.; Forreest, J. C.; Gerrard, D. E. and Edwar, W. M. (2001) - *Principles of meat science*. 4<sup>a</sup>. ed. Iowa: Kendall/Hunt Publishing Company, 354p.
- ANUALPEC (2007) - Anuário da pecuária brasileira São Paulo, Instituto FNP, 368p.
- Araújo Filho, J. T.; Costa, R. G.; Fraga, A. B.; Sousa, W. H.; Gonzaga Neto, S.; Batista A. S. M. and Cunha, M. G. G. (2007) - Efeito de dieta e genótipo sobre medidas morfométricas e não constituintes da carcaça de cordeiros deslanados terminados em confinamento. *Revista Brasileira Saúde Produção Animal*, vol.8, n. 4, p. 394-404.
- Bickerstaffe, R.; Couter, C. E. and Morton, J.D. (1997) - Consistency of tenderness in New Zealand retail meat. In: *43st International Congress of Meat Science and Technology*. Auckland, New Zealand, ICOMST, p. 196-197.
- Bonagurio, S.; Perez, J. R. O. and Garcia, I. F. F. (2003) - Qualidade da carne de cordeiros Santa Inês puros e mestiços com Texel abatidos com diferentes pesos. *Revista Brasileira de Zootecnia*, vol.32, n.6, p. 1562-1570.
- Brazil (1997) - Ministry of Agriculture, Livestock and Supply. Brazilian Secretary of Agricultural Defense. *Regulation of Industrial and Sanitary Inspection of Animal Products* (Approved by Decree No. 30.691 of 03-29-52, modified by Decrees Nos. 1.255 of 06-25-62, 1.236 of 09-02-94, No. 1.812 of 02-08-96 and No. 2,244 of 06-05-97). DIPOA-MAPA, Brasília-DF, 241p.

- Brazil (1999) - Brazilian Secretary of Agricultural Defense. *Métodos analíticos físico-químicos para controle de produtos cárneos e seus ingredientes: sal e salmoura*. Normative Instruction No. 20, Brasília.
- Bressan, M. C.; Prado, O. V.; Perez, J. R. O.; Lemos, A. L. S. C. and Bonagurio, S. (2001) - Efeito do peso ao abate de cordeiros Santa Inês e Bergamácia sobre as características físico-químicas da carne. *Ciência e Tecnologia de Alimentos*, vol. 21, n.3, p. 293-303.
- Borges, I.; Silva, A. G. M. and Albuquerque, F. H. M. A. R. (2004) - Escrituração zootécnica e sua importância no gerenciamento da caprinocultura. In: *Reunião Técnica Científica em Ovinocaprinocultura*. Itapetinga, Anais UESB, p.1-17.
- Carneiro, P. L. S.; Malhado, C. H. M.; Souza Júnior, A. A. O.; Silva, A. G. S.; Santos F.N.; Santos P. F. and Paiva S.R. (2007) - Desenvolvimento ponderal e diversidade fenotípica entre cruzamentos de ovinos Dorper com raças locais. *Pesquisa Agropecuária Brasileira*, vol. 42, n.7, p. 991-998.
- Costa, C. A. R.; Araújo, C. V. and Araújo, S. I. (2006) - Índice biométrico para avaliação do desenvolvimento corporal em ovinos da raça Santa Inês por meio de análise multivariada. In: *V Seminário de iniciação científica da UFRA*. Belém, Anais UFRA.
- Devine, C. E.; Graafhuis, A. E.; Muir, P. D. and Chrystall, B.B. (1993) - The effect of growth rate and ultimate pH on meat quality of lambs. *Meat Science*, vol.35, n.1, p. 63-77.
- Dransfield, E.; Nute, G. R. and Hogg, B. W. (1990) - *Carcass and eating quality of ram, castrated ram and ewe lambs*. Langford, UK: British Society of Animal Production., publication, 50p.
- Ekiz, B.; Yilmaz, A.; Ozcan, M.; Kaptan, C.; Hanoglu, H.; Erdogan, I. and Yalcintan, H. (2009) - Carcass measurements and meat quality of Turkish Merino, Ramlic, Kicircik, Chios and Imroz lambs raised under an intensive production system. *Meat Science*, vol. 82, n.1, p. 64-70.
- Ferrão, S. P. B.; Bressan, M. C.; Oliveira, R. P.; Perez, J. R. O.; Rodrigues, E. C. and Nogueira, D.A. (2009) - Características sensoriais da carne de cordeiros da raça santa inês submetidos a diferentes dietas. *Ciência e Agrotecnologia*, vol 33, p.185-190.
- França, F. M. C.; Holanda Júnior, E. V. and Martins, E. C. (2006) - Análise econômica e financeira de um modelo teórico de produção de carne ovina e caprina para unidades familiares no semi-árido do Rio Grande do Norte. In: *Criação familiar de caprinos e ovinos no Rio Grande do Norte: orientações para viabilização do negócio rural*. Natal, Brasil: Embrapa Caprinos, p. 121-144.
- Frescura, R. B. M.; Pires, C. C. and Silva, J. H. S. (2005) - Avaliação das proporções dos cortes da carcaça, características da carne e avaliação dos componentes do peso vivo de cordeiros. *Revista Brasileira de Zootecnia*, vol.34, n.1, p. 167-174.
- Hwang, H. I.; Park, B. Y.; Cho, S. H. and Lee, J. M. (2004) - Effects of muscle shortening and proteolysis on Warner-Bratzler shear force in beef Longissimus and Semitendinosus. *Meat Science*, vol.68, p.497-505.
- IBGE (2007) - Instituto Brasileiro de Geografia e Estatística. *Banco de Dados Agregados*. Available at: <<http://www.sidra.ibge.gov.br/>>. Viewed on: Jan. 2, 2014.
- Johnson, M. H.; Bidner, T. D.; Mcllin, K. W.; Dugas, S. M. and Hembry, F.G. (1989) - The effect of three temperature conditioning treatments and subcutaneous fat removal on lamb quality. *Journal of Animal Science*, vol. 67, p. 2309-2315.
- Kerth, C. R.; Blair-Kerth, L. K. and Jones, W. R. (2003) - Warner-Bratzler shear force repeatability in beef Longissimus steaks cooked with a convection oven, broiler, or clam-shell grill. *Journal of Food Science*, vol. 68, n.2, p. 750-756.
- Koohmaraie, M.; Whipple, G.; Kretchmar, D. H.; Crouse, J. D. and Mersmann, H. J. (1991) - Postmortem proteolysis in longissimus muscle from beef, lamb and pork carcasses. *Journal of Animal Science*, vol. 69, p. 617-624.
- Louvandini, H.; Nunes, G. A.; Garcia, J. A. S.; Mc Manus, C.; Costa, D. M. and Araújo, S. C. (2007) - Desempenho, características de carcaça e constituintes corporais de ovinos Santa Inês alimentados com farelo de girassol em substituição ao farelo de soja na dieta. *Revista Brasileira de Zootecnia*, vol. 36, n.3, p. 603-609.
- Lyon, B. G. and Lyon, C.E. (1997) - Sensory descriptive profile relationship to shear values of deboned poultry. *Journal of Food Science*, vol. 62, p.885-888.
- Madruga, M. S.; Araújo, W. O. and SOUSA, W. H. (2006) - Efeito do genótipo e do sexo sobre a composição química e o perfil de ácidos graxos da carne de cordeiros. *Revista Brasileira de Zootecnia*, vol. 35, p. 1839-1844.
- Meilgaard, M.; Civille, G. V. and Carr, B. T. (2006) - *Sensory Evaluation Techniques*, 4th Ed., Boca Raton, FL, USA, CRC Press, p. 448.
- Monteiro, E. M.; Rübensam, J. and Pires, G. (2001) - Avaliação de parâmetros de qualidade de carcaça e da carne de ovinos. In: *1º Congresso Brasileiro de*

- Ciência e Tecnologia de Carnes*. São Paulo, Brasil, p. 98-99.
- Neres, M. A.; Monteiro, A. L. G.; Garcia, C. A.; Costa, C.; Arrigoni, M. B. and Rosa, G. J. M. (2001) - Forma física da ração e pesos de abate nas características de carcaça de cordeiros em creep feeding. *Revista Brasileira de Zootecnia*, vol.30, n.3, p. 948-954.
- Oliveira, I.; Silva, T. J. P.; Freitas, M. Q.; Tortelly, R. and Paulino, F. O. (2004) - Caracterização do processo de rigor mortis em músculos de cordeiros e carneiros da raça Santa Inês e maciez da carne. *Acta Scientiae Veterinariae*, vol. 32, n.1, p.25-31.
- Osório, J. C. S.; Osório, M. T. M. and Jardim, P. O. C. (1998) - *Métodos para avaliação de carne ovina "in vivo" na carcaça e na carne*. Pelotas, Ed. UFPEL, 107p.
- Ribeiro, E. L. A.; Rocha, M. A.; Mizubuti, I. Y.; Silva, L. D. F.; Ribeiro, H. S. S. and Mori, R. M. (2001) - Carcaça de borregos Ile de France inteiros ou castrados e Hampshire Down castrados abatidos aos doze meses. *Ciência Rural*, vol.31, n.3, p. 479-482.
- Rosa, G. T.; Pires, C. C. and Motta, O. S. (2000) - *Composição tecidual dos cortes da carcaça de cordeiros (as) em diferentes métodos de alimentação e pesos de abate*. Reunião Anual da Sociedade Brasileira de Zootecnia, Viçosa, Anais SBZ.
- Santana, A. F. de.; Costa, G. B. and Fonseca, L. S. (2001) - Correlação entre peso e medidas corporais em ovinos jovens da raça Santa Inês. *Revista Brasileira de Saúde e Produção Animal*, vol.1, n.3, p. 27-30.
- Santello, G. A.; Macedo, F. A. F.; Mexia, A. A.; Sakaguti, E. S.; Dias, F. J. and Pereira, M. F. (2006) - Características de carcaça e análise do custo de sistemas de produção de cordeiros ½ Dorset Santa Inês. *Revista Brasileira de Zootecnia*, vol. 35, n.4, p. 1852-1859.
- SAS (2003) - *User's guide statistics*. Cary: INSTITUTE SAS, 959p.
- Silva Sobrinho, A. G.; Machado, M. R. F.; Gastaldi, K. A. and Garcia, C. A. (2005) - Características de Qualidade da Carne de Ovinos de Diferentes Genótipos e Idades ao Abate. *Revista Brasileira de Zootecnia*, vol. 34, n.3, p. 1070-1078.
- Sousa, V. S.; Louvandini, H.; Scropfner, E. S.; Mcmanus, C.; Abdalla, A. L. and Garcia, J. A. S. (2008) - Desempenho, características de carcaça e componentes corporais de ovinos deslanados alimentados com silagem de girassol e silagem de milho. *Ciência Animal Brasileira*, vol. 9, n.2, p. 284-291.
- Souza, X. R.; Bressan, M. C.; Pérez, J. R. O.; Faria, P. B.; Vieira, J. O. and Kabeya, D. M. (2004) - Efeitos do grupo genético, sexo e peso ao abate sobre as propriedades físico-químicas da carne de cordeiros em crescimento. *Ciência e Tecnologia dos Alimentos*, vol. 24, n.4, p. 543-549.
- Thompson, J. (2002) - Managing meat tenderness. *Meat Science*, vol. 62, n.3, p. 295-308.
- Tornberg, E.; Wahlgren, M. and Brondum, E. S. B. (2000) - Pre-rigor conditions in beef under varying temperature and pH falls studied with rigometer, NMR and NIR. *Food Chemistry*, vol. 69, p. 407-418.
- Zundt, M.; Macedo, F. A. F. and Astolpho, J. L. L. (2006) - Desempenho e características de carcaça de cordeiros Santa Inês confinados, filhos de ovelhas submetidas à suplementação alimentar durante a gestação. *Revista Brasileira de Zootecnia*, vol. 35, n.3, p. 928-935.