Trop Anim Health Prod (2015) 47:883–887
DOI 10.1007/s11250-015-0803-x

REGULAR ARTICLES

Effects of processing corn on the carcass traits and meat quality of feedlot lambs

Letícia Silva Oliveira[1] · **Madeline Rezende Mazon**[1] · **Roberta Ferreira Carvalho**[1] · **Domingos Marcelo Cenachi Pesce**[2] · **Saulo Da Luz E Silva**[1] · **Sarita Bonagurio Gallo**[1] · **Paulo Roberto Leme**[1]

Received: 13 November 2014 / Accepted: 25 March 2015 / Published online: 8 April 2015

Abstract The objectives of this study were to evaluate and compare the effect of the corn grain processing (whole grain, dry beans ground, and wet grain) on carcass characteristics and meat quality in lambs. Twenty-two Dorper vs. Santa Inês uncastrated lambs (27±4 kg BW; ±3 months old) were distributed in a randomized complete block (initial BW). The diets were composed of 20 % protein-mineral pellet, 5 % hay, and 75 % corn in the form of whole grain, ground grain, or wet grain. The harvest weight of animals fed whole corn (50.2 kg) and ground (49.03 kg) were equal and higher than the moisture corn fed lambs (44.89 kg); therefore, the same differences were expected to be seen in the cold vs hot carcass comparison. However, there was no difference between treatments comparing hot or cold carcass performance, averaging 47 and 46 %, respectively. Also unaffected by the treatments were subcutaneous fat thickness values, loin muscle area, pH, temperature, drip loss, water loss by cooking, color, and tenderness. It can be concluded that the shape and size of corn grain in diets of high concentrate resulted in no measurable influence on carcass traits, but whole grain is more easily managed by the producer.

Keywords Carcass lambs · Energy diet · High-moisture corn · Protein pellet · Whole corn

✉ Madeline Rezende Mazon
mad-mazon@usp.br

[1] Faculty of Animal Science and Food Engineering, Sao Paulo University, 225 Duque de Caxias Av, 13635-900 Pirassununga, SP, Brazil

[2] Department of Veterinary Medicine, Catholical University Pontifical of Minas Gerais *campus* Poços de Caldas, 1661 Padre Francia Cletus Cox Av, Poços de Caldas, MG, Brazil

Introduction

Due to difficulties in handling large amounts of roughage, the physical limitations that high forage diets provide in relation to the rumen filling, and the high cost of land, have led to the adoption of feedlot finishing lamb with the use of high levels of concentrates (Gallo et al. 2014).

The main energy source in the ruminant diet is the corn, and the efficiency and use of the grain depend on its form of processing; this is especially true for the type of corn used in Brazil, which corn dominates the hard grains fed. The milling of dry corn is the process most widely used by farmers in order to increase the surface area of the grain to facilitate the ruminant digestive processes (Millen et al. 2009). This kind of food offered in large quantities can present some practical problems such as inadequate secretion of saliva and reducing ruminal motility, due to a lack of fibrous structure, which impairs rumination. In contrast, when whole grains are used in the diet, the grains are not damaged as greatly during chewing and digestion is limited, but the sheep still are apparently able to use efficiently the grain in this form (Orskov 1986, Gallo et al. 2014).

The designation of corn moisture is determined by the moisture content of the grain at harvest, and a moisture content of 35–40 % is recommended for quick and favorable fermentation of the product in the silo (Kramer and Voorsluys 1991). This favors an increase in the digestibility of grain through the rupture of the protein matrix surrounding the starch granules. This disruption may be caused by the presence of organic acids resulting from the fermentation process, enabling greater daily weight gain and improved feed efficiency (Ítavo et al. 2006). The metabolic and digestive problems in lambs fed diets based on processed cereals can be solved when the grain is offered whole rather than ground or high humidity. Due to the smaller exposed surface area, whole grain is fermented more slowly than the processed grains, and animals spend more time chewing feeding and eliminating the occurrence of disturbances (Russel and Rychlik 2001).

This study aimed to evaluate the effect of diets with high concentrate containing grain processed in different forms (whole grain, dry beans ground, and wet grain) on quantitative and qualitative characteristics of carcasses and meat from lambs.

Material and methods

The experiment was conducted in the Department of Animal Science, Faculty of Animal Science and Food Engineering, University of São Paulo, Pirassununga, SP. Twenty-two Dorper vs. Santa Inês uncastrated lambs (27±4 kg BW; ±3 months old) were allocated in 1.2 m×2.0 m individual experimental pens, which had covered feedbunk, waterer, and concrete floor.

The lambs were adapted to the diets during the last 14 days on feed before the experimental period. During this period, the concentrate was increased daily to meet expected levels in treatments. After the adaptation period, the complete diet was offered ad libitum once daily in the morning.

The animals were fed for a 65-day period with the experimental diets containing elevated proportion of concentrate and the various types of processed corn: whole grain, ground grain, or wet grain. The experimental diets were composed of 75 % corn, 20 % of pelete mineral-proteinic (Grano Entero®), and 5 % grass hay coast-cross (Table 1).

Corn grains used were DOW 2B707, semi-hard texture-treated nets Cruiser® FS 350 from Dow AgroScience. The moisture corn was ensiled in plastic 109 days after sowing, and it was harvested at 40 % moisture content. The milling of the high-moisture corn before the ensiling process was performed using the Silotress Poetter model OP20 series 00200. The silo containing the high-moisture corn was opened 6 months after the ensiling process.

Table 1 Composition of experimental diets on dry matter basis

Composition (%)	Corn processing		
	Whole	Ground	Wet
Dry matter	7.19	7.27	7.29
Protein (PB)	16.85	16.57	15.37
Ether extract (EE)	4.20	5.05	5.15
Extract not nitrogen (ENN)	69.20	68.31	71.22
Acid detergent fiber	8.84	7.38	5.84
Neutral detergent fiber	17.99	18.29	12.18
Total digestible nutrients[a]	77.19	77.74	78.93
Calcium	0.99	1.00	1.01
Phosphorus	0.39	0.39	0.39

[a] Values are estimated by the equation % TDN=40.2625+0.1969 % PB+ 0.4228 % ENN+1.1903 % EE 0.1379 % FB

The dry corn was harvested 157 days after sowing, when the corn kernels met a moisture content of 19 %. The grains were dried until they met 13 % moisture, allowing its storage in grain silos.

Regarding the physical description of the corn grains, the geometric mean diameter was 5.84 mm for the wet corn grains, 1.30 mm for ground corn grains, and 5.99 mm for the whole corn grains. The dry grains were ground on a 3-mm sieve.

After 65 days post feedlot entry, the animals were weighed on fasting to determine the final body weight and harvested in Harvesthouse-School Coordinator at the campus of the University of São Paulo, *campus* of Pirassununga, Brazil. The animals were anesthetized by pressure gun use and the sangria made by cutting the main arteries and veins in the jugular region.

After evisceration, carcasses were identified and weighed to obtain hot carcass weight. One hour after harvest, the pH (pH 1h) was measured as well as the carcass temperature (T °C 1h) in the semimembranosus muscle region. Thereafter, the carcasses were transferred to the cold chamber and cooled at 1 °C for 24 h. After a 24-h period, the carcasses were again weighed to determine the cold carcass weight, and the pH (pH 24h) and temperature (T°C 24h) were measured. The cooling loss was calculated by the difference in carcass weights. The methodology used was adapted from Cezar and Souza (2007).

Carcasses were deboned and the left hemi-carcass of each animal was sectioned between the 12th and 13th rib, and backfat thickness was measured using a ruler graduated in millimeters. The loin muscle area was determined in the *longissimus dorsi* muscle through a transparent reticulated grid with measurements in square centimeters, according to the methodology proposed by Cezar and Souza (2007).

Three steaks, 2.5-cm-thick *longissimus dorsi* muscle in the region between the 10th and 13th rib, were taken from each animal. Samples were identified, vacuum packed, and frozen at −18 °C to perform the laboratory analyses related to color and tenderness.

A portable colorimeter was used for objective evaluation of meat color, which operates in the CIELAB system. The samples were thawed to room temperature and were immediately removed from the container and allowed to sit at rest for 20 min with the surface exposed to the environment for myoglobin oxygenation. Three measurements of each sample were taken from three different points of the steak, by taking the average of the L^*(lightness), a^* (redness), and b^* (yellow content) values (adapted from Cezar and Souza 2007).

Sequence in the samples were weighed (Pi) in previously tared aluminum pans in a semianalytical scale accurate to ±0.01 g. Then the samples were baked and subsequently weighed again (Pf), thereby determining the loss of water by boiling [Drip Loss=(Pi−Pf)/Pi] expressed in percentage.

The samples were baked in a preheated 170 °C electric oven until the internal temperature reached 71 °C. Shortly thereafter, after the temperature of the cooked samples came to equilibrium with the ambient temperature of approximately 28 °C, the steaks were wrapped with plastic film and refrigerated for 24 h in a household refrigerator with a temperature of about 5 °C.

After 24 h of cooling, two cylinders 12-mm diameter of each steak were taken to determine the shear force (FC), a total of six cylinders per sample. Each cylinder was evaluated for shear strength (in kg) with the device type Warner Bratzler Shear Force mechanic, considering for each sample the mean value obtained from the six cylinders (adapted from Cezar and Souza (2007)).

The experimental design was randomized complete blocks (initial BW), with three treatments and eight replicates per treatment. Data were analyzed by GLM procedure of SAS software model 9.1 (SAS Inst. Inc., Cary, NC). Means were compared by Tukey's test at a significance level of 5 % when there were significant statistical effects by ANOVA on performance.

Results

Final body weight was 50.2 kg for lambs fed whole grain corn, 49.03 kg for the group fed ground corn, and 44.89 kg for the lambs fed high-moisture corn (Table 2). There was an effect of the treatments on final body weight (P=0004). The animals that received moisture corn had lower final body weight than those who received whole kernel corn, which there was no difference with the corn meal.

Lambs fed high-moisture corn had lower hot carcass weight (P=0.04) than other treatments (Table 2), which is a consequence of lower final body weight observed in animals of this treatment. There was no effect of processing corn grain on hot carcass yield (47.51 %) and cold carcass yield (46.25 %). Average of the loss of cooling, subcutaneous fat thickness, and area of ribeye were 2.54 %, 2.73 mm, and 15.54 cm^2, respectively. The pH and temperature 1 and 24 h after harvest were normal, and values described by treatment have been shown in Table 2.

There was no significant difference (P=0.62) between treatments for water loss through cooking for the parameters of meat color and lightness (L*), redness (a*), and yellow content (b*) and the meat tenderness (Table 3).

Discussion

Urano et al. (2006) studied Santa Ines lambs fed high concentrate and harvested at 35 kg bodyweight, which were observed values for hot and cold carcass yield of 48.9 and 47.7 %, respectively, similar to this experiment. Queiroz et al. (2008) evaluated Santa Ines lambs fed diets with a ratio of 90 % concentrate, but with different protein sources and harvested at 39.5 kg, which had a carcass yield of 50.6 %. The loss from cooling was considered normal and as described by Russo et al. (2003) who found similar values in lamb carcasses evaluated by the "Classification System American". The data from this experiment, as well as other authors, indicate that

Table 2 Body weight and carcasses trait of lambs fed different types of corn grain (mean, standard error (SE), probability (P))

	Corn processing				
Variables	Whole	Ground	Wet	SE	*P*
Number of animals	8	6	8		
Harvest weight (kg)	50.2a	49.03a	44.89b		*
Hot carcass weight (kg)	23.15ab	23.90a	21.35b	0.50	*
Hot carcass yield (%)	46.15	48.77	47.62	0.55	ns
Cold carcass weight (kg)	22.84a	22.97a	20.81b	0.49	*
Cold carcass yield (%)	45.52	46.82	46.42	0.41	ns
Drip loss (%)	1.36	3.79	2.48	0.54	ns
Subcutaneous fat thickness (mm)	3.25	2.83	2.12	0.24	ns
Loin muscle area (cm^2)	15.50	15.66	15.47	0.33	ns
pH 1h	6.39	6.53	6.47	0.04	ns
pH 24h	5.70	5.75	5.75	0.04	ns
Temperature (°C) 1 h	37.89	38.38	37.89	0.18	ns
Temperature (°C) 24 h	1.11	1.57	1.29	0.10	

Means followed by different lowercase letters in the same row differ by Tukey test

ns not significant

*Significant at 5 % probability

Table 3 Water loss through cooking for the parameters of meat color and lightness (L*), redness (a*), and yellow content (b*) and the meat tenderness of lambs fed different grains of corn (mean, standard error (SE), and probability (P)

	Corn processing				
	Whole	Ground	Wet	SE	*P*
Number of animals	8	6	8		
Cooking loss (%)	17.81	19.46	18.25	0.72	ns
*L**	28.93	31.29	31.78	0.60	ns
*a**	15.73	16.01	15.37	0.30	ns
*b**	15.06	15.58	16.06	0.34	ns
Tenderness (kg)	4.50	4.39	4.68	0.21	ns

Means followed by different lowercase letters in the same row differ by Tukey test

ns not significant

*Significant at 5 % probability

diets containing high concentrate produce a carcass with a low weight loss in the cooling.

The lack of difference between treatments for backfat thickness can be explained by the fact that the diets have similar energy levels and contain the same proportion of concentrate. However, when evaluating the values for backfat thickness, ranging from 2 to 3.5 mm, it is sufficient to protect the carcass in the freezer, as seen through the low values of cooling losses, around 2.5 %.

The value of loin muscle area was considered compatible with the high-quality carcasses. A similar result was obtained by Urano et al. (2006), who found a value of 14.8 cm^2 loin muscle area. Almeida Júnior et al. (2004) evaluated three different levels (0, 50, and 100 %) of dried corn for corn wet grain with Suffolk lambs fed creep feeding, which observed significant effect on loin muscle area, with 11.73 vs. 13.12 vs. 12.98 cm^2, respectively, indicating an increase in deposition of muscle tissue in animals receiving the highest amount of moisture corn in the diet. When evaluating the data obtained in this experiment and Almeida Júnior et al. (2004), one might argue that diets with higher amounts of grain provided greater loin muscle area on the lamb carcasses.

Reis et al. (2001) evaluated Bergamácia x Corriedale crossbred lambs weaned at 50 days of age and fed diets formulated with grains of dry corn, silage corn, or hydrated moisture corn and harvested at 33 kg harvest weight. The authors also found no effect of treatments on loin muscle area, whose average was 12.51 cm^2, lower than that found in this experiment.

The pH values and carcass temperature 1 h after harvest and cold carcass after 24 h were within the normal range, with no significant difference between treatments (Sañudo et al. 1996).

The results of water loss by cooking may be considered to be low as described by the authors as Queiroz et al. (2008) who evaluated the *Longissimus* of Santa Inês lambs, used electric furnace at 170 °C and the cooking loss found 29.58 to 30.05 %. Bressan et al. (2001) use a pre-heated plate at 150 °C until the internal temperature of the sample reached 72 to 75 °C and found values of cooking loss varying between 27.2 and 33.1 %.

No difference between treatments for the color parameters was observed. In crossbred Santa Ines, described average values are from 32.46 to 42.29 for L^* (lightness), 10.39 to 13.89 for a^* (redness), and 6.73 to 8.15 for b^* (yellow content) (Bressan et al. 2001). In this study, probably no difference was observed on color, since all the animals received the same proportion of concentrate: roughage, the same age, and slaughter weight.

The tenderness of lambs was evaluated and analyzed through shear force. There was no treatment effect on tenderness, but the values were higher than that found by Queiroz et al. (2008) who evaluated the strength of shear force of *longissimus dorsi* muscle from lambs Santa Ines, whose average was 3.95 kg. Almeida Júnior et al. (2004) evaluated the meat of lambs fed three different levels (0, 50, and 100 %) of dried corn for moisture corn in the diet and found no difference between treatments for shear force, whose average value was 2.84 kg.

According to Bressan et al. (2001), difference in shear force values occur due to several factors, such as pre- and post-harvest handling, speed in rigor mortis, in post-mortem pH, temperature pre-harvest storage conditions, and methodology for determinations. The shear strength values obtained in this experiment can be considered good, since Abularach et al. (1998) defined as a maximum 5 kg for meat to be considered soft. The similarity of the results of tenderness between treatments in this study is due to the fact that the lambs are harvested young, with a maximum age of 6 months and the same finishing system.

Conclusion

Therefore, the various methods of processing the corn do not have influence on carcass traits and meat lambs. The use of whole corn grains and ground corn provides higher carcass weight, hot and cold. We highlight the advantage of using whole grain corn in feeding lambs because it is more economical, there is no processing expense, and it is more convenient for the producer.

Statement of animal right Research Ethics Committee - Animal Area USP process number: 2011.1.929.74.6

Conflict of interest The authors declare that they have no conflict of interest.

References

Abularach, M.L.S.; Rocha, C.E.; Felício, P.E. 1998. Características de qualidade do contrafilé (músculo longissimus dorsi) de touros jovens da raça Nelore. Ciência e Tecnologia de Alimentos, v.18, n.2, p.205–210,

Almeida Júnior, G.A.; Costa, C.; Monteiro, A.L.G.; Garcia, C.A.; Munari, D.P.; Neres, M.A. 2004. Qualidade da carne de cordeiros criados em *creep feeding* com silagem de Grãos Úmidos de Milho. Revista Brasileira de Zootecnia, 33, 4, 1039–1047.

Bressan, M.C.; Prado, O.V.; Pérez, J.R.O.; Lemos, A.L.S.C.; Bonagurio, S. 2001. Efeito do peso ao abate de cordeiros Santa Inês e Bergamácia sobre as características físico-químicas da carne. Ciência Tecnologia de Alimentos, 21, 3, 293–303.

Cezar, M. F.; Souza, W. H. 2007.Carcaças ovinas e caprinas: obtenção, avaliação e classificação. Uberaba, MG: Agropecuária Tropical. 147 p.

Gallo, S. B.; Merlin, F.A., Macedo, C. M.; Silveira, R. D. O. 2014. Whole grain diet for Feedlot Lambs. Small Ruminant Research, 120, 185–188.

Ítavo, C.C.B.F.; Morais, M.G, Ítavo, L.C.V, Souza, A.R.D.L.; Oshiro, M.M.; Biberg, F.A.; Costa, C.; Jobim, C.C.; Lempp, B. 2006. Efeitos de diferentes fontes de concentrado sobre o consumo e a produção cordeiros na fase de terminação. Revista Brasileira de Zootecnia, 35, 1, 139–146.

Kramer, J.; Voorsluys, J.L. Silagem de milho úmido, uma opção para gado leiteiro. In: SIMPÓSIO SOBRE NUTRIÇÃO DE BOVINOS, 4., 1991, Piracicaba. Anais… Piracicaba: Fundação de Estudos Agrários Luiz de Queiroz, 1991. p.257-262.

Millen, D.D.; Pacheco, R.D.L.; Arrigoni, M.D.B.; Galyean, M.L.; Vasconcelos, J.T. 2009.A snapshot of management practices and nutritional recommendations used by feedlot nutritionists in Brazil. Journal of Animal Science, 87, 3427–3439.

Orskov, E.R. 1986. Starch digestion and utilization in ruminants. Journal of Animal Science, 63, 1624–1633.

Queiroz, M.A.A., Susin, I., Pires, A.V., Mendes, C.Q., Gentil, R.S., Almeida, O.C., Amaral, R.C., Mourão, G.B. 2008. Desempenho de cordeiros e estimativa da digestibilidade do amido de dietas com diferentes fontes proteicas. Pesquisa Agropecuária Brasileira, 43, 9, 1193–1200.

Reis, W.; Jobim, C.C.; Macedo, F.A.F.; Martins, N.; Cecato, U. 2001. Características da carcaça de cordeiros alimentados com dietas contendo grãos de milho conservados em diferentes formas. Revista Brasileira de Zootecnia, 30, 4, 1308–1315.

Russel, J. B.; Rychlik, J. L. 2001. Factors that alter rumen microbial ecology. Science, 292, 1119–1122.

Russo, C., Preziuso, G., Verita, P. 2003. EU carcass classification system: carcass and meat quality in light lambs. Meat Science, 64, 411–416

Sañudo, C.; Santolaria, M.P.; María, G.; Osório, M.; Sierra, I. 1996. Influence of carcass weight on instrumental and sensory lamb meat quality in intensive production systems. Meat Science, 42, 2, 195–202.

Urano, F.S.; Pires, A.V.; Susin, I.; Mendes, C.Q.; Rodrigues, G.H.; Araujo, R.C.; Mattos, W.R.S. 2006. Desempenho e característica da carcaça de cordeiros confinados alimentados com grãos de soja. Pesquisa Agropecuária Brasileira, 41, 1525–1530.