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Carcass characteristics and tissue composition of the meat of feedlot lambs fed high-grain diets

Características da carcaça e composição tecidual da carne cordeiros confinados com o uso de dietas de alto grão

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Abstract

This study aimed to evaluate the effect of using different high-grain diets on the carcass characteristics and tissue composition of the meat of feedlot-finished lambs. Thirty-two male castrated Texel lambs born from single births and weaned at approximately 50 days of age were allotted to treatments that consisted of different unprocessed grains, as follows: corn grain, white oat grain, black oat grain, or grain of rice in the husk. The animals were slaughtered upon reaching the pre-established slaughter weight of 32 kg, which corresponds to 60% of the mature weight of their mothers. Lambs fed the high-corn grain diet had higher weights and yields of hot and cold carcass and larger loin-eye areas than those finished in the feedlot receiving high-grain diets based on white oat, black oat, or rice in the husk. Additionally, they had a higher degree of fatness and a thicker subcutaneous fat layer at slaughter, which lead to decreased cooler shrink loss. The neck, shoulder, ribs, and leg cuts were heavier in lambs fed the high-corn grain diet. By contrast, these lambs had a lower proportion of leg, more rib, and higher meat fat content, which may be undesirable for the consumer market. The use of high-corn grain diets, in comparison with high-grain diets based on black oat, white oat, and rice in the husk, may be recommended for finishing lambs in the feedlot when they are slaughtered at similar weights.
Key words: Loin eye area. Conformation. Degree of fatness. Yield. Texel.

Resumo

O objetivo desse trabalho foi avaliar o efeito do uso de diferentes dietas de alto grão sobre as características da carcaça e a composição tecidual da carne de cordeiros terminados em confinamento. Foram utilizados 32 cordeiros machos, castrados, da raça Texel, nascidos de parto simples e desmamados com aproximadamente 50 dias de idade. Os tratamentos foram constituídos por diferentes tipos de

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grãos, não processados, sendo: grão de milho, grão de aveia branca, grão de aveia preta ou grão de arroz com casca. Os animais foram abatidos assim que atingiram o peso vivo de abate pré-estabelecido de 32 kg, que corresponde a 60% do peso adulto de suas mães. Os cordeiros alimentados com dietas de alto grão de milho apresentam maiores pesos e rendimentos de carcaça quente e fria e maior área de olho de lombo quando comparados com cordeiros terminados em confinamento com o uso de dietas de alto grão a base de aveia branca, aveia preta ou arroz com casca. Além disso, apresentaram maior estado de engorduramento e espessura de gordura subcutânea no momento do abate, o que leva a redução do índice de quebra ao resfriamento das carcaças. Os pesos de pescoço, paleta, costilhar e perna foram superiores nos cordeiros terminados com o uso de dieta de alto grão de milho. Por outro lado, apresentaram menor proporção de perna, maior de costilhar e maior proporção de gordura na carne, fatores estes que pode ser indesejado pelo mercado consumidor. O uso de dieta de alto grão de milho em comparação ao uso de dietas de alto grão de aveia preta, aveia branca ou arroz com casca pode ser recomendada para a terminação de cordeiros em confinamento quando esses são abatidos com pesos semelhantes.

Palavras-chave: Área de olho de lombo. Conformação. Estado de engorduramento. Rendimento. Texel.

Introduction

The demand for quality lamb meat has aroused the interest of breeders in finishing lambs in the feedlot, which intensifies production systems, and in reducing losses of young animals due to nutritional deficiency and/or parasitic infection. Additionally, feedlotting allows for maintaining a regular meat supply to the market and obtaining a faster return on the invested capital as a result of earlier slaughter and a more uniform end product for the consumer (FRASSON et al., 2016).

In terms of the feeding regime adopted in the feedlot, diets with high levels of energy concentrates offer advantages over those with increased participation of roughage components in that the former are easily standardized, stored, and handled, in addition to providing rapid gains in carcass fat and weight in confined animals. As such, they allow for the intensification of production systems by advancing the time for slaughter and generating better-quality carcasses, in contrast to traditional pasture-based finishing systems (OLIVEIRA, 2013). In this regard, traditional pasture-based sheep meat production systems which usually provide low weight gains and animals slaughtered at an advanced age culminate in the sale of low-quality carcasses, one of the main factors limiting lamb consumption in Brazil (VENTURINI, 2015).

However, major commercial centers have exhibited an increasing consumption of quality lamb with elaborate cuts and carcasses with maximum amounts of muscle, minimum proportions of bone, and a fat content that varies according to the consumer's preference. Moreover, this fat should be sufficient to ensure the juiciness of the meat as well as its appearance and to protect the carcass (PAIM et al., 2011).

On these grounds, the present study was developed to evaluate carcass characteristics of feedlot-finished lambs fed high-grain diets as well as the effect of these diets on the tissue composition of their meat.

Material and Methods

The experiment was carried out at the Sheep Farming Laboratory in the Department of Animal Science of the Federal University of Santa Maria, located in Santa Maria - RS. Brazil, from August to November 2012. Thirty-two castrated male Texel lambs born from single births and weaned at approximately 50 days of age were used.

The animals were allocated to four treatments in a completely randomized design with eight replicates. Treatments consisted of different unprocessed grains, as follows: corn grain (*Zea mays*), white oat grain (*Avena sativa*), black oat grain (*Avena strigosa*), or grain of rice in hulls (*Oryza sativa* L.). The diet consisted of the whole grain used in the treatment, 15% of a commercial concentrate mixture (89.29% DM, 36.58% CP, 64% TDN, 2.5% Ca, and 0.0009% P), soybean meal, and dicalcium phosphate. Diets were formulated to be isoproteic and meet the requirements of the category used, in accordance with the NRC (2007), to provide a daily weight gain of 200 g (Table 1).

Table 1. Proportion of ingredients (%DM) and chemical composition of experimental diets.

	Treatment			
	Corn	White oat	Rice	Black oat
	Proportion of ingredients (%DM)			
Black oat	-	-	-	81.60
White oat	-	77.89	-	-
Rice	-	-	69.95	-
Corn	72.83	-	-	-
Mineral mix	15.00	15.00	15.00	15.00
Soybean meal	11.65	6.63	14.63	2.90
Calcitic limestone	0.52	0.48	0.42	0.50
	Chemical composition (%DM)			
DM	89.14	89.72	88.39	89.60
OM	95.09	94.91	91.95	94.65
CP	18.81	18.81	18.81	18.81
EE	2.56	2.85	1.28	2.24
NDF	14.34	26.25	21.70	22.24
ADF	4.97	13.32	14.52	11.63
TC	73.73	73.25	71.86	73.60
NSC	59.39	47.01	50.16	51.36
Ash	4.39	4.61	7.63	4.85
TDN[1]	82.64	76.15	66.3	73.36
Ca	0.63	0.63	0.63	0.63
P	0.25	0.31	0.31	0.30

[1] Estimated from Valadares Filho et al. (2006).
DM = dry matter; OM = organic matter; PB = crude protein; EE = ether extract; NDF = neutral detergent fiber; ADF = acid detergent fiber; TC = total carbohydrates; NSC = non-structural carbohydrates; TDN = total digestible nutrients; Ca = calcium; P = phosphorus.

Lambs were confined in individual, fully covered 2.0-m^2 stalls with slatted floors at approximately 1.0 m above the soil equipped with individual feed and water troughs. The feed was supplied *ad libitum* twice daily, at 08h00 and 17h00. The amount provided was adjusted according to the leftovers observed daily, which should be 10% of the amount offered on the previous day, so as to ensure maximum voluntary intake. Lambs had *ad libitum* access to mineral salt in individual containers for that purpose. The chemical composition of the mineral salt was 134 g calcium; 60 g phosphorus; 10 mg magnesium; 110 g sodium; 12 g sulfur; 150 mg cobalt; 60 mg iodine; 2,500 mg iron; 4,500 mg manganese; 30 mg selenium; 6,000 mg zinc; 570 mg fluorine (max.); and 180 g flavoring agent. The mineral salt was free of copper, to prevent possible intoxications by this mineral.

The experimental period was preceded by a 10-day period used for the animals to adapt to the feed, facilities, and management conditions. In this stage, for the animals to accustom to eating solid feed from the trough, ground alfalfa hay was provided as part of the feed plus the grain used in the treatment at an initial roughage-to-concentrate ratio of 45:55%. Subsequently, until the start of the experimental period, the alfalfa hay was gradually replaced every two days with 15% of the cereal grain to be used, according to each treatment, until its complete removal. The feeding trial began after the acclimation period and was extended until the moment each lamb would reach the pre-established slaughter weight of 32 kg, which corresponds to 60% of the adult weight of their mothers, as recommended by Butterfield (1988).

Upon reaching the weight defined for slaughter, lambs were deprived of solid feed for 14 h. After this time, they were weighed to determine the slaughter weight (SW), and then slaughtered. After each slaughter operation, the carcass was weighed individually and then chilled for 24 h in a cold room at 2 ºC. The following carcass characteristics were measured: hot carcass weight (HCW), cold carcass weight (CCW), hot carcass yield (HCY, obtained as HCW/SW × 100), cold carcass weight yield (CCY, determined as CCW/SW × 100), and rate of cooler shrink loss (RCSL, calculated as 100 - (CCY/HCY) × 100). Conformation was assessed on the cold carcass of each animal on a scale of 1 (poor) to 5 (excellent). The degree of fatness (DF) was determined on a scale of 1 (emaciated) to 5 (obese), according to methodologies described by Osório et al. (1998).

Next, the loin-eye area was obtained by exposing the *Longissimus dorsi* muscle after a transverse section was made in the carcass between the 12th and 13th ribs; its outline was then traced onto tracing paper (MÜLLER, 1980). SITER 3.1 software model A2 was used to determine and record the area, as described by Giotto (2001). In the same region, following Osório et al. (1998), backfat thickness was measured with a caliper and texture was evaluated subjectively. In this step, we observed the size of fiber bundles oriented lengthwise in the muscle and assigned a score of 1 to 5 (1 = too thick, 2 = thick, 3 = medium, 4 = thin, and 5 = too thin). Marbling was determined according to the amount of intramuscular fat observed in the *Longissimus dorsi* muscle, also on a scale of 1 to 5 (1 = inexistent, 2 = little, 3 = good, 4 = too much, and 5 = excessive). Lastly, the color present on the cut was assigned a score of 1 to 5 as well (1 = light pink, 2 = pink, 3 = light red, 4 = red, and 5 = dark red). Subsequently, the right half of the carcass was weighed and separated by region into the following cuts: neck, shoulder, ribs, and leg (OSÓRIO et al., 1998). After this separation step, these primal cuts were weighed and their percentage was calculated relative to the cold carcass weight. The right shoulder of each lamb was dissected and separated into the fractions bone, muscle, fat (backfat, scapular fat, and intermuscular fat), and other structures (ganglia, fascia, tendons, and great nerves) to determine the tissue composition of the meat.

After data collection, results were subjected to analysis of variance and means were compared by Tukey's test, adopting the 5% significance level. Analyses were performed using SAS (2004) statistical package. The mathematical model below was used:

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$$

Y_{ij} = observation referring to animal j on treatment i;

μ = overall mean of the observations;

α_i = effect of treatment i; and

ε_{ij} = random error associated with each observation.

Results and Discussion

Slaughter weight did not differ significantly across the treatments, demonstrating uniformity among the experimental units. In the analysis of hot and cold carcass weights and yields, however, the lambs fed the corn grain-based diet showed significantly higher values than those receiving the other treatments (Table 2). This result can be explained by the fact that, irrespective of the treatment, the lambs had homogeneous characteristics at the onset of the experiment in terms of genotype, sex, and age, which suggests this finding is a direct consequence of the feed provided to them. Therefore, one can infer that the lambs on the corn grain treatment had better body development and fat content when compared with those receiving the other treatments, which can be confirmed by their degree of fatness and backfat thickness, which were also higher in that group.

Table 2. Mean values of slaughter weights and carcass traits of the lambs.

Parameter	Treatment				P	CV (%)
	Corn	White oat	Rice	Black oat		
SW (kg)	31.88	31.59	31.46	31.37	0.8695	3.97
HCW (kg)	16.24[a]	13.38[b]	13.76[b]	13.82[b]	0.0001	7.82
CCW (kg)	15.83[a]	13.00[b]	13.36[b]	13.45[b]	0.0001	7.99
HCY (%)	50.89[a]	42.35[b]	43.70[b]	44.06[b]	<0.0001	6.23
CCY (%)	49.61[a]	41.14[b]	42.43[b]	42.89[b]	<0.0001	6.39
RCSL (%)	2.51[b]	2.85[a]	2.92[a]	2.69[a]	0.0476	11.98
CC (1-5)	3.37	2.69	2.75	2.86	0.0678	18.15
DF (1-5)	3.69[a]	2.94[b]	2.67[b]	3.00[b]	0.0367	20.90
BFT (mm)	3.37[a]	1.94[b]	1.67[b]	1.71[b]	0.0011	36.92
Texture (1-5)	3.31	3.12	3.33	3.50	0.8315	23.54
MARB (1-5)	3.06	2.50	3.08	2.78	0.4856	28.86
Color (1-5)	3.50[a]	2.75[b]	3.33[ab]	2.93[ab]	0.0465	18.74
LEA (cm^2)	16.66[a]	12.24[b]	12.97[b]	13.07[b]	0.0004	13.56

SW = slaughter weight; HCW = hot carcass weight; CCW = cold carcass weight; HCY = hot carcass yield; CCY = cold carcass yield; RCSL = rate of cooler shrink loss; CC = carcass conformation; DF = degree of fatness; BFT = backfat thickness; MARB = marbling; LEA = loin-eye area.
Means in the same row followed by different letters differ by Tukey's test at the 5% significance level.

The carcass yield is known to be greatly influenced by the effect of the gastrointestinal content weight at the time of slaughter (LAWRENCE; FOWLER, 2002). In the present experiment, although the lambs were deprived of solid feed for 14 h pre-slaughter, when the chemical composition of the experimental diets was evaluated, the corn grain-based diet showed to have a lower proportion of slowly digestible or completely indigestible fraction of feedstuffs, as represented by NDF and ADF; a larger proportion of the fraction of greater digestibility; and a higher rate of passage through the gastrointestinal tract, as represented by non-structural carbohydrates (Table 1). This aspect might have influenced the results of carcass yield across the treatments, with the lambs fed black oat, white oat, and rice in hulls displaying larger proportions of gastrointestinal content (23.53%, 22.84%, and 22.54%, respectively) at slaughter in comparison with those fed corn grain (11.07%). These findings corroborate Pires et al. (2006), who evaluated carcass characteristics of feedlot-finished Ile de France × Texel crossbred lambs receiving diets with different fiber contents and observed that a reduction in the dietary NDF content led to improved carcass yields. Those authors attributed this result to a decrease in gastrointestinal content at the time of slaughter.

Findings similar to those observed in the current study for the hot and cold carcass yields of lambs receiving the corn grain-based treatment were obtained by Borges et al. (2011), who examined the effects of different levels of substitution of corn grain for black oat on the performance of feedlot Texel lambs. The authors observed, for control treatment (no substitution; diet containing 84.75% whole grain corn) mean hot and cold carcass yields of 52.33% and 50.59%, respectively.

The rate of cooler shrink loss indicates the percentage of weight that is lost during the carcass chilling process. Lower losses occurred in the meat of lambs fed the corn grain diet, which may be considered a direct effect of the backfat thickness and degree of fatness of animals. As stated by Osório and Osório (2003), the backfat works positively by protecting the carcass from dehydration during chilling, preventing darkening of the outer part of muscles, in addition to not compromising the meat quality. The indicated value of 2.73% regardless of the treatment can be considered normal for shrink loss, considering that such losses should be between 3.0 and 4.0%, according to Carvalho et al. (2017).

Loin-eye area was larger in the lambs receiving the corn grain treatment (Table 2), and this can be considered a consequence of the higher growth rate (BERNARDES et al., 2015) and cold carcass weight of animals receiving that treatment. This may be viewed as a positive aspect regarding carcass quality, since, as stated by Cartaxo and Sousa (2008), an increase in loin-eye area will lead to larger amounts of muscle in the carcass. A smaller area of 11.22 cm^2 was observed by Pires et al. (2006); however, that value is near those obtained by the lambs receiving the other treatments, in the present experiment.

The corn treatment resulted in meat with higher color values than the white oat diet, but did not differ from the rice or black oat treatments. According to Sousa et al. (2008), the color plays an important role in the sensory quality of meat and stands out as the main factor of appreciation at the time of purchase.

Despite the distinct periods of confinement of the lambs on different treatments as a function of the observed differences in weight gain (BERNARDES et al., 2015), the animals were slaughtered at similar live weights. Therefore, the weights of neck, shoulder, ribs, and leg were higher (P<0.05) in the group fed the high-corn grain diet (Table 3), as they showed the best cold carcass yield and weight of all treatments, which mean heavier cuts from their carcass.

Table 3. Mean values of weights and percentages of commercial cuts extracted from the lamb carcasses.

Parameter	Treatment				P	CV (%)
	Corn	White oat	Rice	Black oat		
Neck (kg)	0.676^a	0.597^b	0.584^b	0.600^b	0.0492	11.43
Shoulder (kg)	1.491^a	1.217^b	1.260^b	1.234^b	<0.0001	8.14
Ribs (kg)	3.191^a	2.489^b	2.402^b	2.626^b	<0.0001	10.42
Leg (kg)	2.451^a	2.161^b	2.286^b	2.203^b	0.0173	7.84
Neck (%)	8.67	9.23	8.77	9.01	0.4135	7.85
Shoulder (%)	19.08	18.87	18.99	18.56	0.5782	3.94
Ribs (%)	40.89^a	38.42^b	36.10^c	39.36^{ab}	0.0001	4.12
Leg (%)	31.40^b	33.54^a	34.48^a	33.04^a	0.0028	4.22

Means in the same row followed by different letters differ by Tukey's test at the 5% significance level.

Lambs on the treatment with high grain corn had the lowest percentage of leg in the carcass, which may be viewed a negative aspect according to Araújo Filho et al. (2007), who declared that the leg is considered the most noble of sheep carcasses, as it contains the largest accumulation of muscle mass. Moreover, it is normally the cut of highest commercial value, which depreciates the animal carcass from the economic standpoint.

By contrast, the proportion of ribs in the lambs fed the high-corn grain diet was larger than that observed in the lambs consuming white oat and rice in hulls, but did not differ from the black oat treatment. Considering the assertion of Kempster et al. (1987), this result can be explained by the fact that fat deposition in the carcass is faster via the loin and ribs. This finding might thus be associated with greater deposition of fat in that region in the animals fed the higher-energy diets.

Similar results were reported by Carvalho et al. (2005), who evaluated feedlot-finished lambs of different genotypes and obtained Texel lambs slaughtered at an average live weight of 37.73 kg with mean values of 7.43% neck, 20.52% shoulder, 39.29% ribs, and 32.74% leg.

The muscle portion in lambs fed the high corn-grain diet was heavier than that observed in all other treatment groups, which is positive for that diet from the consumer's standpoint. Similarly, the weights of subcutaneous, internal, and total fats were higher in the corn-grain treatment (Table 4). The higher weight of tissues in the lambs on that treatment is a consequence of their heavier shoulder cut in relation to the lambs receiving the high-grain diets based on white oat, black oat, and rice in hulls.

Table 4. Mean values of weights and proportions of different lamb meat tissues.

Parameter	Treatment				P	CV (%)
	Corn	White oat	Rice	Black oat		
Muscle (kg)	0.786[a]	0.659[b]	0.683[b]	0.669[b]	0.0008	8.41
Bone (kg)	0.242	0.227	0.233	0.233	0.4246	7.60
SUBF (kg)	0.086[a]	0.057[b]	0.052[b]	0.053[b]	<0.0001	20.30
SCAF (kg)	0.044	0.033	0.027	0.023	0.1063	48.94
INTF (kg)	0.204[a]	0.127[b]	0.139[b]	0.146[b]	0.0012	23.11
TF (kg)	0.334[a]	0.217[b]	0.219[b]	0.222[b]	0.0003	21.11
OTH (kg)	0.088	0.072	0.077	0.075	0.2188	20.17
Muscle (%)	52.69	54.22	54.55	54.43	0.3480	4.13
Bone (%)	16.33[b]	18.78[a]	18.65[a]	18.98[a]	0.0016	7.29
SUBF (%)	5.75[a]	4.70[b]	4.17[b]	4.26[b]	0.0048	17.60
SCAF (%)	2.90	2.64	2.22	1.91	0.3278	44.49
INTF (%)	13.76[a]	10.32[b]	11.01[b]	11.81[b]	0.0458	20.17
TF (%)	22.42[a]	17.66[b]	17.41[b]	17.97[b]	0.0171	17.17
OTH (%)	5.87	5.96	6.19	6.05	0.9448	17.12

SUBF = subcutaneous fat; SCAF = scapular fat; INTF = intermuscular fat; TF = total fat; OUT = other structures.
Means in the same row followed by different letters differ by Tukey's test at the 5% significance level.

When the tissue components were evaluated in percentage terms, the proportion of muscle did not differ significantly across the treatments, averaging 53.91%. The percentage of bone, in turn, was lower, whereas the percentages of subcutaneous, intermuscular, and total fats rose in the lambs fed corn grain in comparison with the other treatment groups. This increase in fat content may be explained by the higher energy content of the diet based on corn grain provided to the animals. This result may be considered negative from the consumer-market perspective, since excess fat repels consumers, which are increasingly concerned with healthy eating habits.

Results in line with ours were obtained by Klein Júnior et al. (2008), who evaluated the shoulder tissue composition in Ideal crossbred lambs and found mean bone and muscle contents of 19.7% and 53.4%, respectively, in castrated animals. However, the fat content detected by those authors in the shoulder was 22.3%, which is slightly higher than that found in this study. Rosa et al. (2002) observed similar values (19.8% bone, 59.6% muscle, and 20.2% fat) in Texel lambs slaughtered at 33 kg live weight.

Conclusions

The use of high-corn grain diets, as compared with high-grain diets based on black oat, white oat, or rice in the hulls, can be recommended for the finishing of feedlot lambs when they are slaughtered at similar weights, as they provide improved quantitative and qualitative carcass traits, which are important from the production standpoint and for the consumer market.

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