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Whole grains in the finishing of culled ewes in pasture or feedlot: Performance, carcass characteristics and meat quality

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ABSTRACT

In order to evaluate the performance, carcass characteristics and meat quality of culled ewes finished in pasture or exclusively with grain, 41 culled Polwarth ewes, were assigned to six treatments: RY (ryegrass pasture), RYGO (ryegrass and whole grain oats), RYGM (ryegrass and whole grain maize), GM (whole grain maize), GO (whole grain oats), GS (whole grain sorghum). The finishing system of the ewes influenced weight gain, wherein the GM and GS treatments increased daily weight gain. The GO treatment decreased the dressing percentage. Nonetheless, a^*, h^*, pH, cooking loss and tenderness were similar across dietary treatments. Using principal component analysis, the variables C18:2n6, h^*, n6/n3, TBARS, total lipids, L^* and b^* were assigned as characteristics of meat from the feedlot animals, while the pasture finishing system produced meat with higher CLA and n-3 fatty acids but lower TBARS values indicating lipid stability.

1. Introduction

Ewes have a peak reproductive performance, and when this potential decreases after six years of age they must be replaced in order to maintain the efficiency of the herd (Chaturvedi, Sankhyan, Mann, & Karim, 2008). During this period, in order to obtain the best financial returns regarding the productive system, culled ewes are slaughtered. In many countries, about 40% of the animals that are slaughtered are ewes that have a low body condition score; the meat is tough and generally less preferred by consumers (Bhatt, Soren, Sahoo, & Karim, 2013). Thus, to avoid slaughtering ewes with a low body condition, as well as to have a good carcass performance, increased meat quality, and economic gain; a suitable finishing system is required.

Where natural grazing resources exist, sheep are reared in extensive systems, however, annual pastures, such as ryegrass (*Lolium multiflorum*) are widely used. Furthermore, feedlots are used to intensify the finishing of animals, to accelerate commercialization and for the production of well finished carcasses. Concentrated maize grain is mainly used in the finishing of sheep because it is a rich source of starch (Liu, Xu, Liu, Zhu, & Mao, 2014; Yahaghi et al., 2012). Surplus grain production, or other available ingredients, should be considered as alternatives to replace maize grain in order to reduce costs without interfering with the productive performance. Sorghum grain (Yahaghi et al., 2012) and oats (McGregor & Whiting, 2013; Sormunem-Cristian, 2013) are two such alternatives.

Diets influence productive aspects (Bhatt et al., 2013), as well as meat characteristics such as colour, lipid oxidation, fat deposition and fatty acid profile (Luciano et al., 2012; Tansawat, Maughan, Ward, Martini, & Comforth, 2013). Therefore, this study was conducted in order to evaluate the performance, carcass characteristics and meat quality of culled ewes finished in the following manner: solely with pasture; with pasture and a supplementation with whole grain; on feedlot with a diet containing a high level of whole grain.

2. Materials and methods

2.1. Animal, diet and performance

This study was conducted at the Farroupilha Federal Institute, São Vicente do Sul Campus, RS, Brazil, with geographic coordinates 29° 41′30″S and 54° 40′46″W. A total of 41 culled ewes of the Polwarth breed, 5.83 ± 1.03 years old, with a body condition score of 1.77 ± 0.31 (on a scale of 1 = excessively thin, to 5 = excessively fat) were randomly assigned to the following six treatments: RY (animals finished in ryegrass pasture); RYGO (ryegrass + 1.5% of the live weight of whole grain oats); RYGM (ryegrass + 1.5% of body weight of whole grain maize); GM (feedlot with 72% whole grain maize + 13% soybean meal + 15% protein concentrate); GO (feedlot with 90% whole grain oats + 10% protein concentrate); and GS (feedlot with 80% whole grain sorghum + 5% soybean meal + 15% protein concentrate). The

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moisture (M), crude protein (CP), ether extract (EE) and ash were determined in accordance with the method of AOAC (2005). Neutral detergent fibre (NDF) was determined according to Van Soest, Robertson, and Lewis (1991) and the non-fibre carbohydrate (NFC) fraction was determined by difference (NFC = 100 − (CP + EE + ASH + NDF). Total digestible nutrients (TDN), calcium and phosphorus values were estimated according to the NRC (2006) (Table 1).

It is important to note that the ewes were finished using two distinct systems in paddocks containing the offer of 12% of the live weight of ryegrass and a supply of whole grains for the treatments with supplemented diet, or the feedlot system in 6 m^2 pens per animal with whole grains and protein supplement to balance the diet, totalling a supply of 4% of body weight. To evaluate the effect of high grain diet, animals that received only pasture were considered as control. All the animals received water ad libitum and the sheep that were grazed on pasture received mineral supplement ad libitum. The estimated consumption was 20 g/day (mineral composition per kg of product: 82 g calcium, 60 g phosphorus, 132 g sodium, 11.7 g sulphur, 11.7 mg chromium, 30 mg cobalt, 350 mg copper, 600 mg fluorine, 50 mg iodine, 700 mg iron, 1200 mg manganese, 180 mg molybdenum, 15 mg selenium, 2600 mg zinc).

After the distribution of animals in experimental unit (paddocks or pens), the ewes went through an adaptation period of 30 days. The ewes were weighed on the first day, and during the experiment at intervals of 14 days, after a period of solid fasting for 14 h. They were then slaughtered, after a period of solid fasting of 14 h, following humanitarian practices when they reached a body condition score (BCS) of 3 (on a scale of 1 = excessively thin, to 5 = excessively fat), according to the classification of Osório et al. (1998).

2.2. Characteristics of carcass and non-carcass components

After slaughter, the non-carcass components of each animal were weighed. The carcasses were weighed before and after cooling to 4 °C for 24 h to obtain the dressing percentage (calculated as the rate between cold carcass and pre-slaughter weight) and chilling loss (percentage of the difference between the yield of hot and cold carcass). In accordance with Osório et al. (1998), the carcasses were characterised (carcass and non-carcass components) and they were subsequently sectioned longitudinally to quantify the weights of the primal cuts. The *longissimus thoracis et lumborum* (LTL) was excised from the right and left halves of the carcass and storage at −20 °C until further analysis.

Table 1
Chemical composition of the feed offered (%DM) of the culled ewes finished in ryegrass pasture (RY), ryegrass and whole grain oats (RYGO), ryegrass and whole grain maize (RYGM), feedlot with whole grain maize (GM), whole grain oats (GO), and whole grain sorghum (GS).

Nutrients[1]	Pasture			Feedlot[4]		
	RY	RYGO[3]	RYGM[3]	GM	GO	GS
CP	15.71	14.85	11.95	17.96	16.02	16.75
EE	3.12	4.27	3.91	4.17	5.29	3.71
NDFa	53.87	36.69	33.10	13.87	19.54	14.69
NFC	15.92	36.41	44.65	59.71	53.84	61.03
TDN[2]	58.00	67.00	73.00	86.07	76.00	81.35
Ash	11.38	7.78	6.41	4.28	5.32	3.82
Ca[2]	0.60	0.33	0.31	3.80	2.55	3.80
P[2]	0.24	0.33	0.27	1.21	0.97	1.19

[1] CP = crude protein; EE = ether extract; NDF_a = Neutral detergent fibre corrected for ash; NFC = non-fibre carbohydrate; TDN = Total digestible nutrients; Ca = calcium; P = phosphorus.
[2] TDN, Ca and *P* values simulated to conform with NRC (2006).
[3] Pasture and concentrate allowance (50:50 ratio).
[4] GM = feedlot with 72% whole grain maize + 13% soybean meal + 15% protein concentrate; GO = feedlot with 90% whole grain oats + 10% protein concentrate; GS = feedlot with 80% whole grain sorghum + 5% soybean meal + 15% protein concentrate.

2.3. Meat quality

The proximate composition of the meat was determined in accordance with the method of AOAC (2005), 30 g of *longissimus thoracis* (LT) muscle portion (LTL), 6th to the 13th thoracic vertebra, was lyophilised (Terroni, LS3000B, BR) to constant pressure. The remaining LT *in natura* was subjected to extraction and quantification of total lipids using the technique proposed by Hara and Hardin (1978), while the esterification of fatty acids was determined according to Christie (1989). The fatty acid profile was determined using gas chromatography (Agilent, 45813-01, USA) equipped with flame ionisation detector (FID) and fused silica capillary column 100 m × 250 μm in diameter (Supelco 2560). The fatty acids were identified by comparing to the retention times of standards of known methyl esters (Supelco Mix 37 components FAME; linoleic acid methyl ester mix (cis/trans); trans-11-vaccenic acid methyl ester; conjugated linoleic acid methyl ester), and the esterified samples. The quantification of fatty acids in mg per g of lipids was performed using the known concentration of the internal standard of methyl tricosanoate (C23:0) and the theoretical correction factor, as well as the conversion factor for methyl ester to fatty acid, according to the methodology proposed by Tonial et al. (2014).

The determination of cholesterol was performed by the enzymatic method with a commercial monoreagent kit, according to Saldanha, Mazalli, and Bragagnolo (2004). Lipid oxidation was measured by quantifying thiobarbituric acid reactive substances (TBARS) using the method of Raharjo, Sofos, and Schmidt (1992) and the results were expressed in mg of malonaldehyde per 1000 g of meat. The pH ultimate (24 h) was measured using equipment with a coupled penetration probe and temperature sensor (Hanna HI99163, BR) which was adjusted immediately before analysis using buffer solution pH 7 and pH 4. The colour of the *longissimus lumborum* (LL) portion, 1st to the 5th lumbar vertebra, was measured using a Minolta colourimeter (Konica Minolta, CR 310 Chroma Meter, JP) with D65 illuminant, 10° standard observer and 8 mm aperture size. Using CIE Lab space it was possible to determine the L^* (lightness), a^* (redness index), b^* (Yellowness index) and h^* (hue angle). For each sample, average values were calculated from quintuplicate readings made on non-overlapping areas of the muscle slice.

To assess the cooking loss, the LL muscle was weighed after thawing for 24 h at 4 °C, and then grilled until it reached an internal temperature of 40 °C, turned and grilled until it reached 71 °C. The final weight was measured and after cooling the beef the cylindrical samples were removed. Six cylindrical portions of LL muscle, cut in the longitudinal direction of the fibre (1 cm diameter), were removed from each sample using a steel cutter with a cylindrical mould to measure the shear force. The Warner–Bratzler shear force (WBSF) measurement was performed using a texture analyser (Stable Micro Systems, TA.XTplus Texture Analyser, UK), and the test speed was 3.30 mm/s.

2.4. Statistical analyses

A completely randomised design was used with six treatments and four replications, totalling 24 experimental units consisting of one animal per experimental unit in the finishing system using only pasture, and two animals in the treatments with supplementation in pasture and in feedlot (three ewes did not adapt to the finishing system: two in feedlot with whole grain oats and one fed on supplementation with whole grain corn). The qualitative data were analysed using the SAS statistical programme, in which the evaluation of residual normality was performed by the Shapiro–Wilk test ($P > 0.05$) and homogeneity was assessed by Levene's test ($P > 0.05$). When the treatment effects were assessed using analysis of variance at 5% significance level, the averages were adjusted by the ordinary least squares method (LSMEANS) due to sample loss, and they were subsequently compared by Tukey's test. In order to evaluate the similarity of the characterisation variables of the *Longissimus thoracis et lumborum* (LTL) muscles, multivariate