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Straw for bedding and forage in fattening lambs: effects on fatty acid composition and sensory characteristics of the *longissimus* muscle

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ABSTRACT

The effect of straw on the fatty acid composition and sensory aspects of the *longissimus* muscle was analysed in 24 entire *Rasa Aragonesa* male lambs (weaned at 45 days) housed for 28 days in two pens (0.90 m^2 per lamb, initial weight 17.7 ± 0.70 kg) until reaching 88 days of age. One group received wheat straw for bedding and forage, whilst the other group had none. Instrumental meat quality variables were similar in both treatments ($P > 0.05$). Lambs with straw bedding presented a higher proportion of C18:0, whereas lambs without straw presented a higher proportion of C15:0 and C17:1 ($P \leq 0.05$), which might indicate a ruminal change. Of the 11 sensory attributes evaluated, none were significantly affected by treatment ($P > 0.05$). However, overall liking tended to be higher for meat from the lambs with straw than without straw ($P = 0.09$). The results from this study suggest that the deprivation of wheat straw during the fattening period has a slight effect on the variables analysed and that the lack of straw does not negatively affect the meat quality.

1. Introduction

In the Mediterranean region, the old traditional sheep production in pastoral systems has given way to more intensive schemes, which nowadays could be considered the conventional system. In Spain, most lambs are fattened within large flocks indoors called cooperative classification centres (CCs). In the most intensive system, lambs are fed indoors with ewe milk and a concentrate-based diet until weaning (45–50 days old) and then receive concentrate and straw at the CC until slaughter. One of the main outputs is the highly appreciated meat from light lambs, which are slaughtered at an age younger than 90 days old and 8.0–12.5 kg of carcass weight (Sañudo et al., 1996). This intensive scheme simplifies the process and reduces farm labour requirements whilst producing a more homogeneous product with reduced production costs. However, CCs have been reducing the use of straw, mainly due to its growing cost.

There are some practical disadvantages associated with the use of straw, as incompatibility with manure drainage systems (Tuyttens, 2005), require a high storage capacity and both bedding and lambs are dirt at the end of the fattening period (Teixeira et al., 2014b). On the other hand, besides providing fibre, straw promotes chewing activity and saliva flow, thus preventing the ruminal pH drop and some digestive disorders that normally occur when concentrate diets are used (Faleiro et al., 2010). To solve some of these problems, Blanco et al. (2014) showed that straw can be included in a pellet. However, the provision of straw as bedding and forage in animal production systems is also widely presumed to be beneficial for the welfare of the animals (Tuyttens, 2005; Teixeira et al., 2012) and thus could be reflected in the quality of the meat (Ferguson and Warner, 2008). Finishing animals in stressful intensive environments may experience excessive glycogenolysis in the muscle, resulting in impaired energy metabolism that may affect different meat quality indicators (Warriss et al., 1994). Straw can provide comfort and is a practical way to stimulate stabled animals (Fraser et al., 1991). Lambs without straw perform more stereotypical behaviours, concentrating more on social relationships because of their barren physical environment (Teixeira et al., 2014a).

Even in ruminants, where a biohydrogenation of dietary fatty acids takes place and the dietary lipid content is lower than in monogastrics, nutritional factors can still affect the fatty acid composition of the intramuscular fat (De Smet et al., 2004). Concentrate

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diets for ruminants can increase available soluble carbohydrates, resulting in lower ruminoreticular pH, which decreases hydrogenase activity, thus affecting fatty acid composition (Tove and Matrone, 1962). A review has shown that concentrate-only diets with no reported supply of straw presented the highest C18:1 percentage and the lowest percentage of total saturated fatty acids (SFAs) in fat deposits of lambs compared to other diets richer in roughage (Bas and Morand-Fehr, 2000).

Few studies related to lamb production have evaluated the effect of straw as bedding and forage on meat quality. Teixeira et al. (2012) reported that the lack of straw does not increase stress levels to the point that it jeopardises productive performance and instrumental meat quality variables, including pH, colour, texture, and cooking losses. Recently, Aguayo-Ulloa et al. (2014) investigated how environmental enrichment affects the fatty acid composition and sensory aspects of light lambs; however, feeder ramps with cereal straw were included in the enriched pens. The aim of our study was to evaluate the effect of wheat straw as bedding and forage on the fatty acid composition and sensory aspects of the *M. longissimus* of finishing light lambs.

2. Materials and methods

The study was carried out at the experimental farm of the University of Zaragoza, Spain (latitude 41°41′N), during the autumn of 2012. The area is located in the Ebro River depression, characterised by a dry Mediterranean climate with an average annual temperature of 15 °C and 317 mm average annual rainfall. The Animal Experimentation Ethics Committee of the University of Zaragoza approved the experimental protocol.

2.1. Study description

Twenty-four healthy *Rasa Aragonesa* single male lambs (weaned at 45 days) with an average live weight of 17.75 (±0.7) kg that were 60 days old at the start of the experiment were used to analyse the effect of wheat straw on instrumental meat quality variables, which are described in detail by Teixeira et al. (2012), and on the fatty acid composition and sensory aspects of the *longissimus* muscle. Two groups of 12 lambs were housed in 2.9 × 3.7 m pens (stocking density 0.90 m^2 per lamb) and fattened for 28 days, with one group receiving wheat straw for bedding and forage and the other group receiving none (maintained in barrier pen). The pen with straw was 10 cm deep at the beginning of the trial and straw was added once a week during the trail. Straw as forage was provided *ad libitum*. Both groups were fed *ad libitum* with pellet concentrate in a feeder, and were also provided fresh water. The commercial concentrate (Ovirum High Energy(r)) contained barley, corn, wheat, vegetable fat, soya tort, sugar cane molasses, calcium carbonate, sodium chloride, and a vitamin mineral corrector (18% crude protein and 3.5 Mcal metabolisable energy/kg dry matter). The wheat straw contained 91.33% dry matter, 93.93% organic matter, and 34% crude protein. All lambs were transported and slaughtered the same day, and pre-slaughter conditions were standardised.

The animals were slaughtered within the weight range of the Ternasco-type category (Sañudo et al., 1996) at a European Union licensed abattoir located in the city of Zaragoza. After overnight lairage in pens with cemented walls and non-skid floors (water available but no food), the lambs were electrically stunned and dressed using standard commercial procedures.

After slaughter, the carcasses were stored in cold rooms at 2 °C for 24 h. Then, the left rack from T1 to L6 vertebrae (normalised cut for lambs by Colomer-Rocher et al., 1988) was removed and transferred to the meat laboratory at the Faculty of Veterinary Medicine of the University of Zaragoza, without disrupting the cold chain. The *M. longissimus* was excised and sampled. The methodology used to analyse carcass traits and instrumental meat quality variables is described in detail by Teixeira et al. (2012). The section from T6 to T10 was vacuum-packed, frozen, and stored at −20 °C to assess fatty acid composition, and the section from T13 to L6 was used for sensory evaluation.

Table 1
Definition of the descriptors used in the sensory analysis of the *M. longissimus*.

Descriptor	Definition
Lamb odour	Odour intensity of cooked lamb
Fat odour	Odour intensity of fat or oil
Tenderness	Facility of chewing with the molars
Juiciness	Liquid expelled by the sample during chewing
Oiliness	Sensation of grease in the mouth after swallowing
Lamb flavour	Flavour intensity of cooked lamb
Fat flavour	Flavour intensity of fat or oil
Rancid flavour	Flavour intensity of rancid fat
Metal flavour	Flavour intensity associated with ferrous sulphate
Acid flavour	Flavour intensity associated with citric acid
Overall liking	General hedonic acceptability of the product by panellists

2.2. Fatty acid composition

To determine the intramuscular fatty acid composition, the fat was extracted using the technique described by Bligh and Dyer (1959), based on chloroform-methanol extraction with BHT as an antioxidant and methylation using KOH in methanol. The methyl esters of fatty acids were analysed by gas chromatography using an HP 6890 gas chromatograph with a capillary column SP 2380 (100 m × 0.25 × 0.20 mm). Identification was performed according to SIGMA(r) standards (Carrilho et al., 2009).

2.3. Sensory evaluation

The section of *M. longissimus* was vacuum-packaged, aged for 72 h at 4 °C, and then frozen and stored at −20 °C until analysis. Sensory analyses were performed in a tasting room with individual booths following the normative ISO 8586-1:1993. Two tasting sessions were held with a trained eight-member sensory panel, with two samples per plate. To avoid the possible effects of the order of presentation and first-order carry-over effects, the samples were presented to panellists in different orders (MacFie et al., 1989). Samples were thawed in tap water at 15–17 °C for 2 h. Then, the meat was wrapped in aluminium foil and cooked in a double plate grill (SAMMIC P8D-2, Azkoitia, Gipuzkoa, Spain) at 200 °C until the internal temperature reached 70 °C, monitored by an internal thermocouple (JENWAY 2000 Stone, Staffordshire, UK). External connective tissue and fat were trimmed, and each sample was cut into eight portions. Each portion was wrapped in aluminium foil, identified, and stored in a warm cabinet at 50 °C until it was served to the sensory panel. The time between cooking and serving was approximately 10 min. To avoid differences in meat colour, samples were served under red light. Each treatment was analysed and compared 11 times for each panel member (88 taster-samples per treatment). The sensory profile and specific training were developed in an additional previous session using samples from animals on each treatment. The analysis was based on 10 sensory descriptors (Table 1) that used a 10 semi-structured point scale (0 = low, 10 = high), which was transformed into a numerical scale (0–10) for the statistical analysis. Additionally, overall acceptability was assessed.

2.4. Statistical analysis

Data were tested for normality before analysis using the Shapiro–Wilk test and examination of the normal plot. The effect