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Effects of an enriched housing environment on sensory aspects and fatty-acid composition of the *longissimus* muscle of light-weight finished lambs

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ABSTRACT

We analysed the effect of enriched housing on the sensory meat quality and fatty acid composition of *longissimus* muscle in 60 entire Rasa Aragonesa lambs, housed indoors for 5 weeks in six pens (10 lambs/pen, 0.95 m^2/lamb, initial weight 17.13 ± 0.18 kg and carcass mean 12.23 ± 0.23 kg); three control pens (barren) and three enriched pens (straw, platform with ramps and a small ramp). The final weight, carcass weight, fatness scores and cooking losses of meat from enriched lambs (EG) were higher and pH 24 was lower ($P \leq 0.05$). The EG lambs had more C18:0 and total SFA ($P \leq 0.05$). Lamb odour and grass odour were more intense in EG ($P \leq 0.05$). Overall liking was higher for EG ($P \leq 0.05$) and associated with tenderness ($P \leq 0.0001$). The results suggest that environmental enrichment can have effects on fatty acid composition and sensory meat quality.

1. Introduction

Currently, in several Mediterranean countries, the final stage of lamb fattening occurs indoors in off-farm cooperative centres (CC). This has a number of benefits for the farmer, such as simplifying the finishing process, reducing labour and improving product homogeneity, but could have negative effects on the animals due to multiple transports, social mixing and barren environments (Aguayo-Ulloa et al., 2013; Miranda-de la Lama et al., 2012). Lambs in CCs are often kept at high densities, where they cannot carry out natural behaviours, but consumers are often unaware of this. Although the growing social interest in animal welfare has produced important changes in European legislation regarding livestock production (María, 2006), recent studies conclude that the main reason consumers buy welfare friendly products is for their improved organoleptic quality, followed by improved welfare (Miranda-de la Lama et al., 2013). Thus, it seems important to include both aspects when analysing the effects of specific production practices.

The benefits of improved welfare should be evaluated from multiple perspectives since apparent benefits for the animal may not be good for the production system (Reed et al., 1993), or for the final product. In some species, such as pigs, there is a strong scientific basis for changes in regulations regarding production systems, which has also been tied with meat quality (Bracke et al., 2006; Hill et al., 1998; van de Weerd & Day, 2009; Vanheukelom et al., 2012), although few studies have compared production systems or handling methods in terms of sensorial quality or fatty acid profiles. In lamb production there is very little information about the effect of potential enriching components on sensorial qualities of meat and fewer still on fatty acid composition. Thus, in this paper we evaluate how environmental enrichment (adding feeder ramps and cereal straw to pens) affects production performance, sensory aspects of meat quality, and intramuscular fatty acid profiles.

2. Methods

The study was carried out using the installations of the Animal Experimentation Service of the University of Zaragoza in the Autonomous Community of Aragon, Spain (41°41′ N). All the lambs were raised, transported and slaughtered according to current regulations of the European Commission (1986) for Scientific Procedure Establishments. Experimental protocols were approved by the Animal Experimentation Ethics Committee of the University of Zaragoza.

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2.1. Study description and ramp design

Sixty healthy Rasa Aragonesa entire male lambs (65 days old) with an average live weight of 17.13 (±0.18) kg were allocated into two treatments (weights were balanced across treatments) according to their pen environment during the finishing phase, which lasted five weeks. Lambs were housed indoors in six pens with 10 lambs each (2.9 × 3.3 m, animal density of 0.95 m^2 per lamb) and three replicates per treatment. Lambs from the enriched group (EG) were maintained in 3 pens with a wooden platform with ramps that provided access to a concentrate hopper (Fig. 1). The platform dimensions were 2.35 m long, 1.55 m wide and 0.35 m high (surface area of platform, 1.67 m^2). The ramp slope was approximately 20°. The platform in the pen was attached to the solid fence that separated each pen, allowing the lambs to feed, explore and exercise or to rest lying down. The EG lambs were provided with cereal straw as bedding (on the floor) and as forage (in a fodder rake). Additionally, a small ramp (0.90 m in length, 0.50 m in width, 0.30 m high and 0.08 m^2 of surface of platform) was placed near the opposite solid fence, but away from the food hopper and fodder rake, to allow lambs to play. Lambs from the control group (CG) were maintained in barren pens of similar dimensions to that used commercially at the CC, without cereal straw as bedding or forage. For hygienic reasons a thin layer of sawdust was added at the beginning of the experiment. All lambs were fed with commercial ground (4–6 mm sieve) concentrate (Ovirum Alta Energía®) containing barley, wheat, calcium carbonate, sodium chloride and a vitamin supplement corrector (18% crude protein and 11.5 MJ metabolisable energy/kg DM). Feeding and water consumption were ad libitum. In both treatments the concentrate hopper was wide enough to allow all lambs to eat simultaneously. Water was provided using a float drinker installed in a corner of each pen. Animals were weighed individually at the beginning (W1) of the experimental period (35 days) and just before slaughter (W2). Feed intake was recorded to calculate the conversion index.

2.2. Meat quality

The animals were slaughtered within the weight range of the Ternasco-type category (Sañudo et al., 1996) at an EU-approved abattoir located in the city of Zaragoza. After overnight lairage, 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. Cold carcasses were weighed at 24 h (at 1–2 °C) in the cold room. Carcass conformation and fatness score were graded according to the European classification system (EEC 2137/92 and 461/93 regulations), the EUROP conformation scale (converted to a 15 point scale) and the carcass fatness scale (converted to a 15^5 point scale). After chilling for 24 h, to determine pH 24 h of the *longissimus dorsi* muscle, we removed the left rack section from T1 to L6 vertebrae (normalized cut for lambs by Colomer-Rocher et al., 1988). The pH was assessed using a portable pH metre (fitted with a penetration electrode 52-00 from Crison), which was inserted into a small incision in the left loin (L2–L3 vertebrae). The pH metre was re-calibrated after every five samples, using two standard buffer solutions at pH 7.02 and 4.00. After that, the cut mentioned above were transferred to the Meat Laboratory at the Faculty of Veterinary Medicine of the University of Zaragoza, without disrupting the cold chain. The *M. longissimus dorsi (thoracic et lumborum)* was removed, wrapped, frozen at −20 °C and stored. The loin was divided into three sections to prepare the samples. The first section from T6 to T10 was vacuum-packed, frozen, and stored at −20 °C to assess fatty acid composition. The second section from T10 to T13 was weighed (mean 145 g), vacuum-packed, frozen, and stored at −20 °C after 72 h of ageing to evaluate cooking losses and perform the Warner–Bratzler test (results are available in a recently published article by Aguayo-Ulloa et al. (2014). Samples were thawed for 24 h in a refrigerator (2–4 °C) in their vacuum-sealed plastic bags before testing. The samples were then weighed (mean 137 g) to obtain the thawing losses (TL%, differences between fresh weight and thawing weight of the sample) and cooked for 35 min in plastic bags at 75 °C in a water bath (GLF-D3006), until the internal temperature of the meat (measured with a penetration thermometer) reached 70 °C, then cooled for 30 min under flowing cold water. Once the samples were cooled to room temperature, they were blotted dry using paper towels and re-weighed. Cooking loss percentage (CL%) was calculated using the difference between thawed weight and cooked weight.

2.3. Fatty acid composition

Lipid extraction and gas chromatography analysis of fatty acid methyl esters was performed as described by Carrilho et al., 2009. First, the fat was extracted in chloroform–methanol according to Bligh and Dyer (1959). The sample was defrosted and milled then 10 g (milled muscle) was mixed for 2 min with 10 ml of chloroform and 20 ml of methanol using an ULTRA-TURRAX (IKA, T25 Basic). After that, 10 ml of chloroform, 10 ml of 0.88% KCl and 4 ml of distilled water were added into the mixture to homogenize again for 2 min with the ultraturrax. The final mixture was centrifuged at 4000 rpm for 10 min. The infranatant outcome was extracted and 10 μl BHT (1 mg/10 ml NaOH) was added and then evaporated with nitrogen, on a sand bath at 55 °C. The second

Fig. 1. Wooden ramps and cereal straw as forage and bedding for lambs (left side). Lambs using the feeder ramp (right side, above) and using the playing ramp (right side, below).