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Sensory quality of lamb following long-term frozen storage

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ABSTRACT

The study analysed the effect of frozen storage duration (FSD) on lamb sensory quality. Trained panel evaluated *Longissimus lumborum* aged for 1 d in unfrozen carcass plus 3 d in modified atmosphere packaging on thawed (1, 9, 15 or 21 month FSD) or refrigerated (0 month FSD) meat. Consumer acceptability test was performed on leg chops (*Semimembranosus*) kept in the same conditions but those chops for the visual test were retail displayed up to 10 d from packaging. FSD differed on texture variables and fresh meat showed intermediate values among thawed meats for trained evaluators. Consumers gave the lowest acceptability to 21 months FSD and preferred 1 month FSD, being all meats 'acceptable'. A third of the population scored fresh meat with the lowest acceptance after consumption, although its visual score remained 'acceptable' 3 d longer than most of thawed meats. As thawed and fresh meats were equally preferred at short display, consumer concerns about thawed meat might be reconsidered.

1. Introduction

World lamb consumption is, approximately, 2 kg per capita and it shows large variations between continents (Sañudo, Muela, & Campo, 2013) and countries. Consumers' profiles also vary among regions in an individual country with local products being well known and liked in their origin regions. For example, the average lamb consumption per capita in Spain was 2.5 kg in 2009, while it accounted for more than 6 kg in some regions (MAGRAMA, 2013). 'Origin' of the lamb has been described as a main factor in consumer decision (Bernués, Ripoll, & Panea, 2012) as it is ascribed to 'typicality' and it is an indicator of guarantee and/or quality for consumers (Rubino, Morand-Ferh, Renieri, Peraza, & Sarti, 1999).

These variations among consumer profiles are due to wide-ranging, socio-economic and cultural trends but also to specific lifestyles of increasingly diversified groups of consumers (Bernués et al., 2012) including cooking and cultural backgrounds (Sañudo et al., 1998). Issues such as future consumer lifestyles, the predicted ageing profiles and the demand for convenience, require the meat industry to be more innovative (Troy & Kerry, 2010), and it is very much linked to the way meat is cooked and consumed (Bernués et al., 2012). In Spain, lamb is perceived as a traditional product which requires long and elaborated cooking preparations (MAGRAMA, 2013), and therefore, convenience will influence especially young people that do not have cooking skills (MAGRAMA, 2013). In this sense, freezing provides the advantage (compared to other preservation methods) of choosing the consumption date after long and variable periods of time and without large changes in the properties of fresh meat. This could be one of the reasons for the observed increase in frozen meat consumption at home in Spanish market from 41.7 (2008) to 81.0 t (2012) (MAGRAMA, 2013), which could be also linked to its lower price when bought in the market (Kim, Frandsen, & Rosenvold, 2011). Furthermore, in the particular case of lamb, freezing could play a main role since it is a seasonal product due to species physiological anoestrus, and this fact could lead to an increase in its price because of its lower availability in the markets in certain periods of the year (Muela, Sañudo, Campo, Medel, & Beltrán, 2010). The contradiction is that although many consumers freeze fresh meat at home in order to extend its storage life (Damen & Steenbekkers, 2007), most would not buy thawed meat nor eat thawed meat in a restaurant (Muela, Sañudo, Campo, Medel, & Beltran, 2009). This shows a lack of knowledge of the restoration operation (Bueno et al., 2013) or about the freezing process in general (Damen & Steenbekkers, 2007) by the consumer.

Vieira, Díaz, Martínez, and García-Cachán (2009) indicated that several studies have proved that frozen storage could affect microbiological quality and physicochemical characteristics where quality deteriorates progressively over storage, being generally thought that frozen meat has lower quality than fresh meat (Damen & Steenbekkers, 2007; Lagerstedt, Enfält, Johansson, & Lundström, 2008). In consequence, there is a current interest in research about freezing technology and its effects on meat quality (Leygonie, Britz, & Hoffman, 2012a) in order to ascertain the effects of factors involved in the freezing process in relation to quality (Vieira et al., 2009). In the case of lamb, there are studies involving frozen storage durations of several weeks (i.e., Kim et al., 2011; or Lind, Harrison, & Kropf, 1971) up to months (i.e., Bueno et al., 2011; Bueno et al., 2013; Bueno, Campo, Cacho, Ferreira, & Escudero, 2014; Moore, 1990a, 1990b). In this sense, Muela et al. (2010) and Muela, Sañudo, Campo, Medel, and Beltran (2012)

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conducted studies to analyse the effect of a FSD up to 6 months on lamb at an instrumental and a sensory level. But, to the best of our knowledge, FSD longer than 10 months have not been reported in depth in light lamb, especially at a sensory level.

Furthermore, the combination of packaging after thawing is an almost unexplored research area and more investigation into their combined effect is thus essential (Kim et al., 2011; Leygonie et al., 2012a). In this sense, Muela, Monge, Sañudo, Campo, and Beltran (2015) studied the effect of FSD up to 21 months on packed lamb at an instrumental level.

The aim of the current study was to evaluate lamb quality at a sensory level (taste and visual tests) of meat which was stored frozen up to 21 months and to assess its properties under display conditions after thawing and when compared with fresh meat.

2. Materials and methods

In a previous study, Muela et al. (2015) analysed the effect of FSD on technological measurements (pH, instrumental measurement of colour, water holding capacity — thawing, exudative and cooking losses assays, instrumental measurement of texture — Warner Bratzler assay, and lipid oxidation — thiobarbituric acid reactive substances assay). This manuscript shows the results of the sensory analysis and the statistical correlations between both studies.

2.1. Sampling

The sampling and storage protocol used was reported by Muela et al. (2015). As an overview, the study used 40 lamb carcasses of the Rasa Aragonesa breed which animals were reared under intensive husbandry conditions (fodder with concentrate and cereal straw ad libitum up to 90 d of age, approximately). The slaughter dates were 21, 15, 9, 1 or 0 month (frozen storage duration, FSD) before the sensory tests were performed, accounting eight male carcasses (cold carcass weight of 11–13 kg, light lamb) for each FSD.

Carcasses were kept under refrigeration conditions up to 24 h post-slaughter then split obtaining the left *Longissimus lumborum* (LL) and leg (primal cut). Samples were vacuum-packaged and frozen in a tunnel (−40.2 ± 4.9 °C, 96.4 ± 2.1% RH, 1–2 m/s air speed, for 15 min) and stored at an average of −18 °C and 96% RH for the correspondent FSD. Both freezing and initial frozen storage conditions were monitored with a data logger *Testo 175-H2* (Testo S.A., Cabrils, Barcelona, Spain).

To perform the assays, frozen samples were thawed in tap water inside their vacuum bags. Once the leg was chopped (12-mm thickness), all samples (LL and leg chops) were modified atmosphere packaged (70% O_2:20% CO_2:10% N_2) with a product/gas ratio of 1:2. The trays used in the taste tests were kept in refrigeration (3.2 ± 1.7 °C) and darkness for 3 d until reaching a total ageing of 4 d. Samples destined to visual test were displayed until completing 10 d of display from packaging.

Meat from the remaining eight carcasses was not frozen (fresh meat treatment: 0 month FSD). Animals followed the same procedures as frozen meat but, instead of freezing and thawing, these samples were packaged in modified atmosphere and refrigerated.

2.2. Taste test with trained sensory panel

This component used nine trained evaluators (UNE-EN ISO 8586, 2014) who tested meat samples based on a quantitative descriptive analysis (UNE-ISO 8587, 2010). Sessions were performed in a controlled sensory analysis laboratory (UNE-EN ISO 8589, 2010) provided with individual booths. After the correspondent display, left LL samples were kept at ambient temperature (20 °C) for 1 h before the analysis in order to achieve an internal muscle temperature of, approximately, 15 °C prior to cooking. Samples were wrapped in aluminium foil and cooked (with the subcutaneous fat side up) on a pre-heated (200 °C) industrial double-grill hotplate *GRS-5* (Sammic S.L., Spain) until the internal muscle temperature reached 70 °C, which was monitored by an internal thermocouple *JENWAY 2000* (Jenway Scientific, Stone, United Kingdom). Once grilled, subcutaneous fat was removed and LL was cut into 2 × 1.2 × 2 cm portions (free of visible connective tissue and fat), wrapped individually in aluminium foil and assigned a single random three-digit code. Samples were kept warm in a heater at 50 °C until they were served (≤10 min after being cooked) in random order according to sample, replicate and assessor. Panelists were asked to cleanse their palate with bread and mineral water at the beginning of the sensory evaluation and between samples to try to make the palate conditions similar for each sample.

The parameters used in the assessments (Table 1) were chosen by the trained sensory panel during a training session where they developed a standardised common vocabulary for describing the sensory characteristics of the meat and agreed upon a list of descriptors and their definitions (Guerrero, 2005). The panel evaluated the samples on a 10-point semi-structured and continuous scale in which intensity ranged from very low (0) to very high (10).

A total of 40 samples, 8 replicates per treatment, were tasted following a balanced design in randomised incomplete blocks with two samples per plate (Cochran & Cox, 1978). Each member of the trained sensory panel received 10 samples in total with 2 samples from each treatment presented at each plate, so that each member of the trained sensory panel tasted all 40 samples over 4 sessions in 2 weeks (2 sessions in one day once a week with a resting period between sessions), obtaining a total of 72 judgments per treatment (0, 1, 9, 15 and/or 21 month frozen storage duration).

2.3. Taste test with untrained sensory panel

Untrained sensory panel population (n = 80) was balanced by gender, where 49% were males and 51% females. The age ranges of the sensory population [24% less than 30 years old (young), 41% between 30 and 50 years old (adult), and 35% older than 50 years old (senior)] was representative of the Spanish population [31% younger than 30 years old, 34% between 30 and 50 years old, and 35% over 50 years old (INE, January, 2013)] and was within the scope and constraints of the experimental design and sample size. The untrained sensory panel population consisted of people that regularly consumed red meat including light lamb (52% consumers have lamb more than three times a month and 62% at least once a month).

A total of 8 sessions were performed in two days and with ten different untrained sensory panel members each. Sessions were developed in a conditioned room following the UNE-EN ISO 8589:2010 recommendations. Untrained sensory panel members were surveyed to make sure that test was performed out properly during the entire assay.

Each member was presented with five samples, one per treatment, served and tasted in random order (MacFie, Bratchell, Greenhoff, & Vallis, 1989). They were asked to cleanse their palate with bread and mineral water at the beginning of the sensory evaluation and between

Table 1
Descriptors used in the taste test of lamb meat with trained sensory panel.

Descriptor	Definition
Lamb odour intensity	Odour associated with the species
Grass odour intensity	Odour associated with grass
Fat odour intensity	Odour associated with fat
Tenderness	Ease of chewing the sample between teeth
Juiciness	Perception of water content in the mouth
Unctuosity	Perception of fat content in the mouth
Lamb flavour intensity	Flavour associated with the species
Acid flavour intensity	Elemental flavour produced by aqueous acid solutions
Fat flavour intensity	Flavour associated with fat
Sour flavour intensity	Elemental flavour produced by aqueous solutions with dissolved substances as caffeine or quinine
Stale flavour intensity	Flavour associated with old meat