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Effect of stunning systems on meat quality of Manchego suckling lamb packed under modified atmospheres

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Abstract

The effects of the type of stunning (TS) [electrically *vs.* gas] and packing in modified atmospheres (MA) [MA-A: 30% CO_2/70% O_2; MA-B: 30% CO_2/69.3% N_2/0.7% CO; MA-C: 40% CO_2/60% N_2] on meat quality (pH), drip losses (DL), water holding capacity (WHC), shear force (SF) and instrumental colour (L^*, and C^* *chroma*) of suckling lamb of the Spanish Manchego breed at 7, 14 and 21 d post-packing was studied. Acceptance of meat samples (on the basis of colour and odour) was determined. In general neither the TS nor the MA affected the pH values. Meat from the gas stunned lambs had the lowest DL ($P < 0.001$ at 14 d post-packing), but lower WHC (more water expelled; $P < 0.01$ at 14 and 21 d post-packing), was more tender ($P < 0.01$) and had higher L^* ($P < 0.001$ at 14 d post-packing) and C^* values ($P < 0.001$) than the electrically stunned group. Similar values of WHC and SF were observed for all MA types but the use of CO in the packs (MA-B) caused less DL, gave the highest C^* values, acceptability and colour stability with time of storage.

Keywords: Lamb meat; Stunning; Electrical; Carbon dioxide (CO_2); Modified atmospheres; Carbon monoxide (CO)

1. Introduction

In the Castilla-La Mancha region, meat from suckling lamb, "lechal" or "lechazo" has its own official label of quality (*"Suckling Manchego Lamb"*, as of 3 April 2001) which justifies its elevated price in the market and guarantees its organoleptic characteristics. However, the increased price factor is of secondary importance on purchase, since consumers are more influenced by such factors as image and quality (Bernabéu & Tendero, 2005). In addition, colour, tenderness and juiciness are the most significant factors at purchase (Vergara, Gallego, García, & Landete-Castillejos, 2003) and these parameters depend on pre- and post-mortem factors (Sañudo, Sánchez, & Alfonso, 1998). These authors suggested that ante-mortem factors such as pre-slaughter handling and type of stunning can alter lamb meat quality. Although electrical stunning is the usual method, some studies (Vergara, Linares, Berruga, & Gallego, 2005) found that meat from suckling lambs stunned with CO_2 was more tender and had lower drip losses than meat from lambs electrically stunned or non-stunned. In other species, studies showed significant changes at the onset of rigor mortis, i.e. in poultry (Savenije et al., 2002) and pigs (Hambrecht et al., 2004) subjected to different stunning methods, factors which are crucial in the ageing of meat.

Among post-mortem factors, the type of gas mixture used in modified atmosphere packaging, and their effect

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on lamb meat quality has been studied (Berruga, Vergara, & Gallego, 2005; Doherty, Sheridan, Allen, McDowell, & Blair, 1996; Kennedy, Buckley, & Kerry, 2004; Shay & Egan, 1990; Vergara & Gallego, 2001). Methods of preservation are also important in the decision to purchase the product by consumers (Barreiro, 2005).

Eilert (2005) confirmed that from 2002 to 2004 the use of modified atmosphere packaging increased from 9% to 13%, mainly due to lifestyle trends that reduce the time available for meal preparation. Also, the effects of the gases normally used in meat packing (O_2, CO_2 and N_2) have been described (Church, 1994; Jeremiah, 2001) including some of their disadvantages, i.e. surface meat discolouration (Luño, Beltrán, & Roncalés, 1998) or acceleration of oxidative processes (Berruga et al., 2005; Jeremiah, 2001). In order to alleviate some of the problems of the gas mixtures currently used, some authors propose incorporation of carbon monoxide (CO) in low concentrations to pack fresh meat (Luño, Roncalés, Djenane, & Beltrán, 2000; Sorheim, Nissen, & Nesbakken, 1999). Using less than 1% of CO in modified atmospheres, means the meat maintains an attractive colour, spoilage from bacterial growth is retarded (Knut & Nolet, 2006) as are oxidative processes (Linares, Berruga, Bórnez, & Vergara, 2007). CO is harmful at high levels, but a concentration of 0.4–1% added to a modified atmosphere is considered to be completely safe for human consumption (Sorheim et al., 2006). Therefore, the *Union Européenne du Comerce du Betail et de la Viande* (UECBV) has proposed a strategy within the European Union to permit the use of this gas in modified atmospheres to preserve fresh meat (Knut & Nolet, 2006). The use of CO was recently allowed (as of July 2004) in primary packages in the USA (Seyfert, Mancini, Hunt, Tang, & Faustman, 2007).

On the other hand, one of the main consumer fears relating to the use of CO is the possible loss of quality due to a break in the cold chain causing deterioration in spite of its attractive appearance (Wilkinson, Janz, Morel, Purchas, & Hendriks, 2006). CO, however, permits the development of off-odours which may warn consumers of possible loss of quality (Knut & Nolet, 2006).

Since the effects of different types of stunning and gas mixtures on the ageing process of lamb meat packed in modified atmospheres is unknown, the objectives of this study were (1) to evaluate the effect of different of stunning systems (electrical *vs.* gas) on the quality of lamb meat packed in three modified atmospheres [high O_2 (MA-A); high CO_2/low CO (MA-B) and no oxygen (MA-C)] and (2) to suggest a packaging atmosphere/stunning method that best preserves quality in Manchego suckling lamb meat.

2. Materials and methods

The research protocol used in this work was previously approved by the Animal Ethics Committee of the University of Castilla-La Mancha, according to guidelines of the Executive Committee 86/609/CEE of 2 November 1986 regarding the protection of animals used in research and for scientific purposes.

2.1. Animals

A total of 25 Spanish Manchega suckling lambs (fed exclusively with milk) and slaughtered at 12.8 ± 0.2 kg of weight from the flock at the Experimental Farm of Castilla-La Mancha University (Albacete, Spain) were used in this study. Lambs were distributed into two groups according to the type of stunning (TS):

- ESL, $n = 15$: at 110 V, 50 Hz for 5 s (electrodes applied on both sides of the head, behind the ears) (Electronarcosis Panel, MAC-01, Bernard, S.L.).
- GSL, $n = 10$: using CO_2, in groups of five in the box, 90% CO_2 for 90 s at the bottom of the well (G. Van Wijnsberghe & Co n.v., Veurne, Belgium) usually used for stunning pigs in the slaughterhouse.

Immediately after stunning, lambs were slaughtered using standard commercial procedures. After 2 h post-dressing, all carcasses were chilled at 4 °C in a conventional chiller for 24 h. Then the *Longissimus dorsi* muscle from both sides of the carcasses was removed and cut into nine portions to determine meat quality.

2.2. Sampling

An ULMA Packaging machine model Smart 500 (Guipuzcoa, Spain) was used for packing. Samples were placed in clear trays (Linpac, Plastic, West Yorkshire, UK), with an oxygen permeability rate of $3.2\ cm^{-3}\ m^{-2}\ d^{-1}$ at 1 atm and 23 °C, and covered by a film with transmission rates of $1\ cm^{-3}\ m^{-2}\ d^{-1}$ for oxygen (23 °C; 50% RH); $5.5\ cm^{-3}\ m^{-2}\ d^{-1}$ for CO_2 (23 °C; 0% RH) and $2.2\ g\ m^{-2}\ d^{-1}$ for H_2O (25 °C; 90% RH). The following modified atmospheres (MA) were compared:

MA-A: 70% O_2 + 30% CO_2.
MA-B: 69.3% N_2 + 30% CO_2 + 0.7% CO.
MA-C: 60% N_2 + 40% CO_2.

Samples from each lamb were used in all three treatments (MA-A, MA-B and MA-C) and all the packs kept at 2 °C. Meat quality was assessed at 7, 14 and 21 d post-packing (i.e. 8, 15 and 22 d post-slaughter).

Before opening the packs:

- Gas composition was checked for all packs and for all storage times using a ChecMate PBI Dansensor (Denmark) gas analyzer. To achieve this, gas samples were drawn into a syringe by inserting a needle through the adhesive foam plastic tape on the lid.
- A panel of five experts evaluated the colour based on overall appearance. Samples were evaluated on a 1–3 scale where 1 = unacceptable (very bad colour or discol-