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Extension of the display life of lamb with an antioxidant active packaging

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ABSTRACT

Fresh lamb steaks were treated with three different preparations of natural antioxidants: one group was packaged with a rosemary active film, the second group was packaged with an oregano active film, and the third group was sprayed on the meat surface with a rosemary extract before packaging in a high-oxygen atmosphere. Samples were stored under illumination at 1 ± 1 °C for 13 days. Metmyoglobin formation, lipid oxidation (TBARS), instrumental colour (CIE a^*), psychrotrophic bacterial counts (PCA), sensory discolouration and off-odour were determined. The use of a rosemary extract, a rosemary active film or an oregano active film resulted in enhanced oxidative stability of lamb steaks. Active films with oregano were significantly more efficient than those with rosemary, exerting an effect similar to that of direct addition of the rosemary extract; in fact, they extended fresh odour and colour from 8 to 13 days compared to the control.

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1. Introduction

The short shelf-life of packed lamb meat is one of the principal concerns for its commercialisation. The shelf-life of refrigerated lamb meat does not usually exceed 10 days before evidence of spoilage (Williams, 1991). Meat colour is probably the most important factor that customers use to assess meat quality (Faustman & Cassens, 1990; Zerby et al., 1999). Meat colour affects the perception of freshness and is important in the buyer's decision to purchase the meat (O'Grady, Monahan, Burke, & Allen, 2000). Change in meat colour is closely associated with pigment and lipid oxidation (Buckley, Morrissey, & Gray, 1995), though excessive bacterial load may also have a role (Brewer, Jensen, Prestat, Zhu, & Mckeith, 2002; Martínez, Cilla, Beltrán, & Roncalés, 2006). Lipid oxidation is a critical point for red meat packaged under aerobic conditions, since it occurs at the same rate as discolouration and faster than microbial growth (Jakobsen & Bertelsen, 2000).

Meat packed in a high-oxygen modified atmosphere and stored under refrigeration maintains the desirable bright-red colour of fresh meat longer than meat packed in air (Penney & Bell, 1993) and prevents microbial growth of anaerobic pathogens (Ogrydziak & Brown, 1982). A disadvantage is that lipid oxidation increases and is one of the primary causes of quality loss in meat during such storage (Renerre & Labadie, 1993), chiefly when antioxidants in the diet, such as vitamin E, are low.

To retard or minimize oxidative deterioration of meat, antioxidants may be added. Synthetic antioxidants have long been used in a variety of foods, but their use has come into dispute due to suspected carcinogenic potential (Chen, Pearson, & Gray, 1992; Imaida et al., 1983) and the general rejection of synthetic food additives by consumers. There is, therefore, a growing interest in the characterization of natural antioxidants.

Herbs and spices have been used for many centuries to improve the sensory characteristics and to extend the shelf-life of foods (Shahidi, Wanasundara, & Janhita, 1992). As a result, considerable research has been carried out on the assessment of the antioxidant activity of many herbs, spices and their extracts when added in a variety of foods and food model systems. Emphasis has been given to herbs of the Labiatae family, particularly rosemary and oregano, which have been reported to possess substantial antioxidant activity (Sánchez-Escalante, Djenane, Torrescano, Beltrán, & Roncalés, 2003a). Oregano, a characteristic ingredient of the Mediterranean cuisine obtained by drying leaves and flowers of *Origanum vulgare* plants, is well known for its antioxidant activity (Economou, Oreopoulou, & Thomopoulos, 1991). Rosemary (*Rosmarinus officinalis*) extracts exhibit a potent antioxidant activity, and are widely used in the food industry. A number of authors have reported the effectiveness of rosemary for achieving high sensory scores and lowering lipid oxidation in various meats: Stoick, Gray, Booren, and Buckley (1991) used 500–1000 ppm in beef steaks; Shahidi et al. (1992) recommended concentrations ranging between 200 and 1000 ppm in various foods; Huisman, Madsen, Skibsted, and Bertelsen (1994) used 0.05% in cooked minced pork; Sánchez-Escalante, Djenane, Torrescano, Beltrán, and Roncalés (2001) used 1000 ppm of rosemary, combined with 500 ppm of vitamin C, in beef patties; Formanek et al. (2001) used 0.25% of a commercial preparation of rosemary which was dissolved in 4% soya oil, in beef

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patties; O'Grady, Maher, Troy, Moloney, and Kerry (2006) used 1000 ppm of rosemary directly added to fresh beef. It has been demonstrated that rosemary extracts effectively inhibited hydroperoxide formation (Frankel, Huang, Aeschbach, & Prior, 1996). The antioxidant activity of rosemary extracts has been associated with the presence of phenolic compounds, which break free radical chain reactions by hydrogen atom donation (Basaga, Tekkaya, & Acikel, 1997).

Inclusion of the active agents, be they antioxidants, antimicrobials or any other, within the packaging material gives rise to active packaging. An active package was defined by Rooney (1995) as a material that "performs a role other than an inert barrier to the outside environment". The aim of the active packaging is to increase the display life of contained products maintaining their quality, safety and sensory properties, without direct addition of the active agents to the product. Developments in antimicrobial active packaging have been reported (Appendini & Hotchkiss, 2002; Quintavalla & Vicini, 2002), but studies on antioxidant active packaging are rarer. Nerín et al. (2006) described the promising results of a new antioxidant active packaging system; a plastic film with an embodied rosemary extract was able to inhibit both myoglobin and lipid oxidation in beef, leading to enhanced display life of meat.

The aim of this work was to investigate and compare the effect of two natural antioxidants (rosemary and oregano extracts) incorporated to an active package filled with a modified atmosphere on the display life of lamb steaks.

2. Materials and methods

2.1. Preparation of samples

Six legs from three lamb carcasses were obtained from the abattoir 48 h postslaughter. Sixty-three steaks of about 60 g weight (1.5 cm thick and about 50 cm^2 surface) were aseptically cut from the central part of the leg, using sterile cutting boards and knives. Each steak was placed into a polystyrene tray of size 15.5 × 21.5 × 2.5 cm and randomly divided into five groups, keeping three of them without allocation to any of the groups. The first group (control 1) was packaged with a modified atmosphere (70% O_2 + 20% CO_2 + 10% N_2) and the second group (control 2) was packaged with another atmosphere (50% O_2 + 30% CO_2 + 20% Ar). Both groups were packaged without extracts. The third group was packaged with active film containing a 4% of a rosemary extract (liquid Amexol; Amerex, Madrid, Spain), prepared according to an innovative procedure protected by European Patent 1477519-A1. The fourth group was packaged with active film containing 4% of an oregano extract (Argolide Química, Barcelona, Spain), also prepared according to EP 1477519-A1. The fifth group was sprayed on the meat surface with rosemary extract (Amexol), 2 ml pure extract diluted in 150 ml *n*-pentane, according to a ratio of 2 ml solution to 50 g meat. Trays from these last three groups were filled with a gas mixture of 70% O_2 + 20% CO_2 + 10% N_2. Gas mixtures were kindly supplied by Abelló Linde S. A. (Barcelona, Spain). Packs were sealed with a polyethylene and polyamide laminate film of water vapour permeability 5–7 g/m_2/24 h at 23 °C and oxygen permeability 40–50 mL/m_2/24 h at 23 °C (Irma, Zaragoza, Spain). The samples were stored under illumination (24 h) at 1 ± 1 °C.

Three samples from each group, randomly taken at selected times (5, 8, 11 and 13 days), plus all three not allocated to any of the groups (time 0), were utilized for subsequent analysis. One of them was used for microbial analysis, another one for sensory analysis, and the third one for colour instrumental analysis and thereafter for the quantification of TBARS. All analyses were performed using both *Semimembranosus* and *Biceps femoris* muscles.

2.2. Meat colour and metmyoglobin analysis

Meat colour was measured at the surface of lamb steaks using a reflectance spectrophotometer (Minolta CM-2002; Osaka, Japan) 30 min after pack opening, in order to allow colour stabilisation on air exposure. CIE L^* (lightness), a^* (redness) and b^* (yellowness) parameters were recorded (CIE, 1978). The average value for each steak was the mean of 10 determinations.

The metmyoglobin (MetMb) percentage of the total myoglobin perceptable at the steak surface was estimated spectrophotometrically, according to Stewart, Zipser, and Watts (1965), by measuring steak surface reflectance at 525 and 572 nm (Minolta CM-2002; Osaka, Japan). The maximum value of the ratios of $(K/S)_{572}$ to $(K/S)_{525}$ at the beginning of the experiment was fixed as 0% metmyoglobin; K and S were the absorption and the scattering coefficients, respectively, and K/S ratios were calculated from reflectivity (R_∞) values using the Kubelka–Munk equation. The value of 100% MetMb was obtained following the same procedure after oxidising a sample in a 1% (w/v) solution of potassium ferricyanide (Ledward, 1970). The average value for each steak was the mean of 10 determinations.

2.3. Lipid oxidation analysis (TBARS)

Lipid oxidation was assessed in duplicate by the 2-thiobarbituric acid (TBA) method of Pfalzgraf, Frigg, and Steinhart (1995), using 10 g of meat. TBARS values were calculated from a standard curve of malondialdehyde and expressed as mg malondialdehyde per kg meat.

2.4. Microbial sampling and analysis

Counts of aerobic psychrotrophic flora were investigated. Two sterile cotton swabs moistened in 0.1% peptone water were used for swabbing 10 cm^2 of meat surface, delimited by a sterile stainless steel template. Swabs were stirred thoroughly in 10 ml of 0.1% peptone water. Serial 10-fold dilutions were prepared by diluting 1 ml in 9 ml of 0.1% peptone water. Two duplicate plates were prepared from each dilution by pouring 1 ml in fluid plate count agar (PCA; Merck; Darmstadt, Germany); plates were incubated at 10 °C for 7 days (ICMSF, 1983). Counts of aerobic psychrotrophic flora were determined from plates bearing 30–300 colonies. Counts were expressed as the $\log_{10}$ of colony forming units per cm^2.

2.5. Sensory evaluation

Meat samples were evaluated by a six-member expert panel, trained according to the method of Cross, Moen, and Stanfield (1978). Three open-discussion sessions were held to familiarise panellists with the attributes and the scale to be used. The attributes studied were: 'red colour', 'discolouration' and 'off-odour'. The attributes "discolouration" and "off-odour" were rated using a 5-point descriptive scale, according to Djenane, Sánchez-Escalante, Beltrán, and Roncalés (2001), using a paper scorecard. Scores for "discolouration" referred to percentage of discoloured surface: 1 = none, 2 = 0–10%, 3 = 11–20%, 4 = 21–60%, and 5 = 61–100%. Scores for "off-odour" referred with the intensity of odours associated to lipid oxidation: 1 = none; 2 = slight; 3 = small; 4 = moderate; and 5 = extreme. The attribute 'Red colour' was scored in the red non-discoloured part of the steak, using also an intensity 5-point scale, in which 1 denoted extremely brilliant fresh meat red and 5 denoted extremely faded red.

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