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Effect of dietary supplementation of vitamin E on characteristics of lamb meat packed under modified atmosphere

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Abstract

The effect of dietary vitamin E supplementation on modified-atmosphere packed lamb meat during storage was studied. Thirty-six weaned male Manchego breed lambs were fed diets supplemented with three different vitamin E concentrations (0, 250, 500 and 1000 mg/kg feed) for an average of 37 days, in the 13–26 kg live weight growth range. Slices of *m. longissimus dorsi* were packaged under modified atmosphere (70% O_2 and 30% CO_2), stored at 2 ± 1 °C in darkness for 14 and 28 days. Meat quality parameters after both storage periods were assessed. Dietary vitamin E supplementation significantly increased α-tocopherol concentration in muscle. Initially, lipid oxidation (TBARS), meat colour and bacterial load were similar in all groups. Lipid and colour oxidation of meat increased significantly ($P < 0.001$) throughout storage. The increase was greater in non-supplemented lambs than in supplemented ones. The bacterial counts after 28 days of storage reached the limit for microbiological shelf life (7 $\log_{10}$cfu/cm^2). Dietary vitamin E supplementation increased the shelf life of meat packaged under modified atmosphere to 14 days. TBARS, pigment oxidation and bacterial load were inside the acceptable limit. The meat maintained its quality for 28 days of storage only when lambs were fed with the 1000 mg/kg dietary supplement, though the bacterial load was at the limit of acceptability.

Keywords: Vitamin E; Modified atmosphere packing; Lamb meat; Lipid oxidation; Pigment oxidation

1. Introduction

The short shelf life of packed lamb meat is one of the main problems in its commercialisation. Usually the shelf life of refrigerated lamb meat does not exceed 10 days before evidence of spoilage (Williams, 1991). Meat colour is probably the most important factor 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 customer's decision to purchase the meat (O'Grady, Monahan, Burke, & Allen, 2000). Change in meat colour is closely associated with lipid and pigment oxidation (Buckley, Morrissey, & Gray, 1995), as well as with bacterial load (Brewer, Jensen, Prestat, Zhu, & Mckeith, 2002). The two most important factors that limit the shelf life of fresh meat are colour and microbial growth, with lipid oxidation being the third most important factor. Nevertheless, for meat packed under aerobic conditions lipid oxidation is not a limitation for storage because it occurs at a slower rate than discolouration and microbial growth (Jakobsen & Bertelsen, 2000).

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Dietary supplementation with an antioxidant produces an increase in lipid and pigment stability. Vitamin E is the primary lipid-soluble antioxidant in biological systems, with α-tocopherol being the most biologically active form. Dietary supplementation with vitamin E increases the amount of α-tocopherol deposited in muscle and fat tissues (Jensen, Lauridsen, & Bertelsen, 1998). The deposition of α-tocopherol in muscle prevents lipid and pigment oxidation since it acts directly on cell membranes (Higgins, Kerry, Buckley, & Morrissey, 1998).

Meat packed under high-oxygen modified atmosphere in refrigeration maintains the desirable bright-red colour of fresh meat (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). Meat packed in modified atmosphere with a moderate level of carbon dioxide (CO_2) (10–20%) inhibits the growth of aerobic meat-spoiling bacteria (Ray, 1996), but a higher proportion of CO_2 (30%) speeds up meat discolouration (Silliker, Woodruff, Lugg, Wolfe, & Brown, 1977).

An approach to overcoming the problem of meat storage and limited shelf life is to use dietary vitamin E supplementation in animals, combined with the use of a modified atmosphere in packing, in order to preserve a fresh appearance and delay microbial growth and lipid and pigment oxidation in refrigerated meat. The purpose of this study was to examine the effect of dietary vitamin E supplementation on lipid oxidation, pigment content and microbiology of lamb meat stored under modified atmosphere during refrigerated storage.

2. Material and methods

Thirty-six weaned male Manchego breed lambs were randomly assigned to one of four dietary treatments (9 lambs per treatment) consisting of one non-supplemented (E0) and three vitamin E-supplemented diets. The first group of lambs was supplemented with 250 mg/kg feed (E250), the second with 500 mg/kg feed (E500) and the third with 1000 mg/kg feed (E1000). The vitamin E supplement was included in a basal diet containing 20 mg vitamin E/kg feed (minimum required for normal lamb nutrition). The nutrient composition of the basal diet is shown in Table 1. Diets were presented as 2.5 mm diameter granules. The lambs were housed in individual pens (1 m^2). Feed, water and barley straw were offered *ad libitum*. Weekly feed intake and live weight were recorded. The fattening period lasted an average of 37 ± 1.5 days, from an initial live weight of 13.2 ± 0.5 to a slaughter weight of 26.2 ± 0.3 kg. The lambs were slaughtered in a commercial abattoir. After a 24 h chilling period (4 °C) pH in *m. longissimus dorsi*, rib level, was measured. The *m. longissimus dorsi* from the right-half carcass was dissected and cut in 4 slices which were randomly assigned to one of three storage periods, initial (0), 14 and 28 days and the fourth slice was vacuum packed and frozen at −20 °C for subsequent α-tocopherol analysis. Muscle slices were packed using BB41 pouches (150 μm, polyamide/polyethylene, 50/100, Cryovac) with low gas permeability (7 cc/m^2/24 h O_2 at 4 °C and 80% Relative Humidity (RH), 150 cc/m^2/24 h CO_2 at 23 °C and 75% RH, water vapour transmission rate (WVTR) was 1.5 g/m^2/24 h at 38 °C and 100% RH) and flushed with 70% O_2 and 30% CO_2 (EAP 20, Carburos Metalicos, S.A.) with a 2:1 gas volume to meat ratio in each pack, using a packing machine type: EV-15-1-CD-SC (Tecnotrip, S.A., Barcelona, Spain).

Samples were kept in darkness at 2 ± 1 °C until analysed. Bacterial load and pigment content were recorded with fresh meat. The slices of meat were vacuum packaged and frozen at −20 °C for the subsequent analysis of lipid oxidation (TBARS). In every case, lipid oxidation analysis was performed within two weeks of freezing. The residual proportion of O_2 in the bag atmosphere for all samples was analysed by a portable O_2 analyser model PAK01P (ABISS, Viry Chatillon, France).

The concentration of α-tocopherol in muscle was determined using the procedure of Cayuela, Garrido, Bañón, and Ros (2003), extracting a duplicate sample with isooctane after alkali saponification and subsequent analysis by high performance liquid chromatography (HPLC) and determination by fluorescence. The results were expressed in μg α-tocopherol/g muscle. Lipid oxidation was assessed by thiobarbituric reactive substance (TBARS) using the 2-thiobarbituric acid method of Botsoglou et al. (1994) as modified by Maraschiello, Sarraga, and García Regueriro (1999). Duplicate samples were used and the results are expressed in μg of malonaldehyde (MDA)/g muscle.

The relative content of myoglobin, oxymyoglobin and metmyoglobin was calculated according to Krzywicki (1979), the rates of meat discolouration were measured as A_{580}–A_{630} (Van den Oord & Wesdorp, 1971) and the extent of oxygen saturation of myoglobin on

Table 1
Nutritional value of the experimental diet (g/kg)

Dry matter	860.2
Crude protein	159.0
Ether extract	49.1
Crude fibre	45.6
Ash	54.9
Calcium	9.0
Phosphorus	3.6
UFV[a]	1.02

[a] Feed Unit for maintenance and meat production