The colour stability of aged lamb benefits from Vitamin E supplementation

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Abstract

This study investigated the effect of Vitamin E (Vitamin E) supplementation on the retail display color of lamb *m. semimembranosus* (SM) and *m. longissimus thoracis et lumborum* (LL) and its interaction with pre-display aging. Treatments were designed in a 2x4 factorial, with 2 Vitamin E treatments (175.7 mg Vitamin E/kg of DM grain feed, or no supplementation for 31 days) and 4 aging periods (5 days in air and 10, 20 and 30 days in CO_2 packs pre display). Retail colour was measured using a ratio of the percent reflectance of light at 630 nm to 580 nm (oxy/met ratio). Muscle Vitamin E concentration ranged from 0.5 up to 3.5 mg/g in both muscles. Across this range, the oxy/met ratio after 60h display increased ($P<0.05$) by about 1.5 units, for all aging treatments in the SM, and by a similar amount in the LL but only for samples aged in CO_2 for 30days. For the SM, Vitamin E concentrations of above 3.0mg/kg are required to improve the oxy/met ratio to an acceptable level (above 3.5). With sufficient muscle Vitamin E concentrations it may be possible to increase the shelf life of lamb cuts to 60 hours. The stabilizing effect of Vitamin E becomes particularly important when meat is aged longer than 10 days before display.

Introduction

Consumers choose to purchase a cut of lamb primarily based on its visual appearance. A cut which appears red is most desirable, while cuts which appear brown often cannot be sold at the full retail price, resulting in an economic loss to the meat industry. This browning of meat is caused by the oxidation of the muscle pigment myoglobin, from the red oxymyoglobin form, to the brown metmyoglobin from. This oxidation process often causes the development of the brown surface colour within 48 hours of retail display.

The formation of metmyoglobin is effected by many factors including storage conditions, aging, nutrition, and packaging (Faustman & Cassens, 1990; Renerre, 1990; Faustman *et al.*, 1998). The colour stability of lamb can be improved by addition of the antioxidant Vitamin E, via nutritional supplementation (Wulf *et al.*, 1995). Vitamin E (α-tocopherol) is a lipid soluble antioxidant, responsible for protecting the cellular membranes from damage by lipid peroxidation. It seems likely that there is a relationship between lipid peroxidation and the formation of metmyoglobin, but the mechanism is yet to be proved (Faustman *et al.*, 1998). Thus the mechanism that Vitamin E protects myoglobin against oxidation is not fully understood.

Many Primal cuts are exported to overseas markets resulting in extended aging of the product. During aging proteases cause the breakdown of cell membranes which often results in premium, more tender cuts of meat. However aging cuts can often lead to a decline in retail colour stability (Wulf *et al.*, 1995) as the surface of meat prematurely turns brown due to the build up of oxidized lipids, free radicals and other oxidation products.

This study investigated the hypothesis that the colour stability of aged cuts of lamb will be stabilized by the addition of Vitamin E through nutritional supplementation. When sufficient Vitamin E is present, cuts of lamb will have an improved retail shelf life of 60 hours.

Materials and methods

Eighty (forty-if I take out ES) 6-8 month old crossbred whether lambs with a live weight of 42.44±0.54 kg (mean±sem) were used for this experiment. Prior to slaughter the lambs were fed for 31 days on a pelleted ration (11 MJ/kg ME 18% crude protein) at a rate of 1.6kg/hd/day. For half of the lambs the diet was supplemented with synthetic α tocopherol (175.7mg/kg Vitamin E), the other half (control) received no supplementation (5.85mg/kg Vitamin E).

After slaughter at a commercial abattoir, carcases were halved and primal cuts were either packed fresh in air for 5 days, or in 99% CO_2 (2:1 gas to muscle headspace) for 10, 20 or 30 days at a temperature of 2°C (n=10). At the end of each period the *m.longissimus thoracis et lumborum* (LL) and *m.semimembranosus* (SM) were dissected from the primals, cut into equal portions 3 cm in thickness, over wrapped with polyvinyl chloride wrap, and displayed under fluorescent lights at 4°C for 96 hours. At the same time samples were taken for analysis of Vitamin E concentration.

Colour measurements were made using a Hunter Lab Mini Scan XE Plus every 12 hours during the display period. Myoglobin oxidation was predicted from the oxy/met ratio calculated as the ratio of light reflectance at 580 and 630 nm (Hunt, 1980). A ratio score of 3.5 was used as a consumer discrimination point, below which the browning of meat becomes evident. Linear mixed effects models (SAS®) were used to test the fixed effects of muscle, aging periods and Vitamin E concentration as a covariate on the oxy/met ratio at 60h display, with animal as a random term.

Results and discussion

Muscle Vitamin E concentration increased with supplementation ($P<0.05$). The muscle Vitamin E concentrations ranged from 0.5 up to 3.5 mg/g in both muscles (figure 1a; SM data only). Among the supplemented animals there was a large variation in the Vitamin E accumulated in the muscle compared to the controls (figure 1a); this variation is not yet understood. Vitamin E had a much greater effect on colour stability in the SM muscle across the range of Vitamin E concentration, the oxy/met ratio at 60h increased ($P<0.05$) by one unit (on average) for all aging treatments (Figure 1a –only 30day data only). In the LL the only effect of Vitamin E was in the 30 days aged treatment (figure 1b). Furthermore at 60 hours retail display most LL samples still had a satisfactory retail display colour, even for the control aged samples, contrasting with the SM, where Vitamin E concentrations of above 3.0mg/kg were required to maintain the oxy/met ratio at an acceptable level (above 3.5; figure 1a).

Aging worsened the oxy/met ratio across both muscles in the control (non-supplemented) samples ($P<0.05$). An effect of aging was evident from 10 days in the SM (data not shown), while in the LL this effect was not evident until 30 days. However these effects were stabilized by the antioxidant activity of Vitamin E, thus underpinning the importance of a Vitamin E supplementation regime when aging lamb meat. This result is supported by Lanari *et al*. (2002), who showed that aged beef had a better colour stability when supplemented with Vitamin E.

Wulf *et al.* (1995) showed that malonaldehyde (an indicator of lipid peroxidation) in the muscle increased linearly with aging periods, however lambs supplemented with Vitamin E significantly reduced levels of this product. Although, the link between lipid peroxidation and colour stability has not yet been proved (Faustman *et al.*, 1998), this suggests a possible mechanism as to the poor colour stability in the aged control samples compared to those supplemented with Vitamin E.

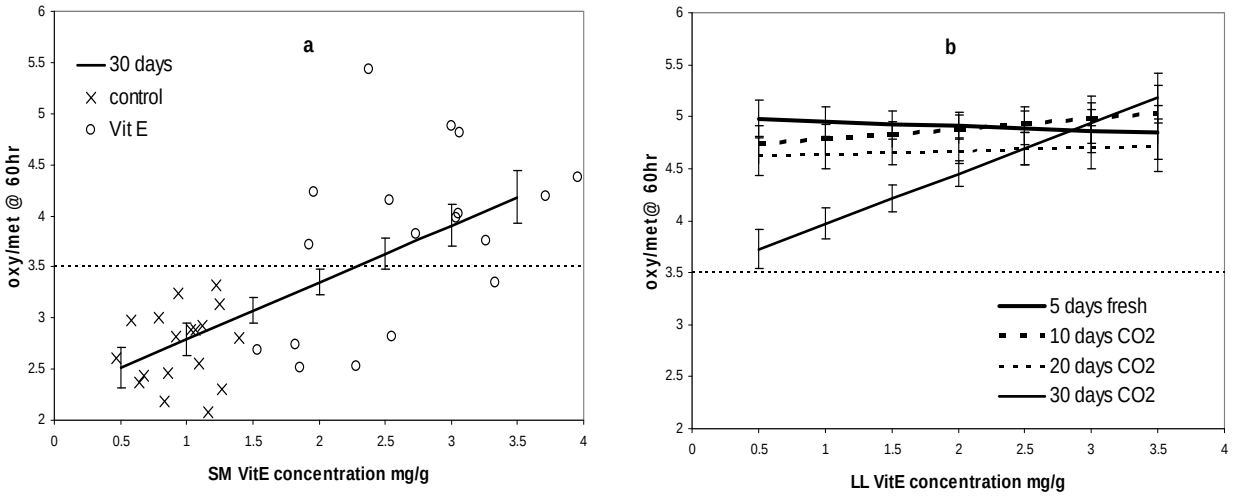

Figure 1. The oxy/met ratio at 60 hours retail display in relation to the muscle vitamin E concentration of the a) SM , 30 day aged samples and b) the LL across all aging periods (Means ± sem).

Conclusions

Vitamin E will improve the colour of aged lamb meat over retail display periods particularly in the more oxidative muscles like the SM. With muscle Vitamin E concentrations greater than 3.0mg/kg tissue it may be possible to increase the shelf life of lamb cuts to 60 hours. The stabilizing effect of Vitamin E becomes particularly important when meat is aged. Without Vitamin E supplementation, SM cuts should not be aged for more than 10 days before display, while LL cuts can be aged for up to 20 days without any detrimental effect on the retail colour stability.

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