THE COLOUR STABILITY OF MINCED BEEF IN HIGH OXYGEN PACKS

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Keywords: myoglobin, MAP, vitamin E

INTRODUCTION

The colour of fresh meat is an important quality attribute influencing the consumer's decision to purchase (Cornforth, 1994). Oxymyoglobin, the oxygenated form of the muscle pigment myoglobin, is primarily responsible for the colour of freshly cut red meats. With prolonged storage, oxymyoglobin oxidises to metmyoglobin which gives meat an unattractive brown colour.

A common to approach to extending the colour shelf-life of fresh red meats is the use of modified atmosphere packaging (MAP). A typical modified atmosphere used for storing red meats is 80% O_2:20% CO_2, in which the high oxygen level (relative to air) serves to increase the depth of the oxymyoglobin layer at the meat surface and the high CO_2 level enhances the microbial stability of the meat. In addition to its positive effect on meat colour, however, oxygen can also promote oxidation reactions in muscle with undesirable effects on colour. Specifically, lipid oxidation reactions may be accelerated in high oxygen atmospheres and oxidising lipids can accelerate oxymyoglobin oxidation to its undesirable brown form, metmyoglobin (Renerre, 1990; Anton et al., 1991). On the other hand, antioxidants such as vitamin E, which protect lipids from oxidation, may indirect stabilise oxymyoglobin from oxidation in high oxygen packs (O'Grady et al., 1996).

In this study, the colour stability of minced beef samples, with a range of native vitamin E levels, stored in high oxygen packs was determined.

MATERIALS AND METHODS

Beef samples. *M. biceps femoris* samples were obtained 24 h *postmortem* from Romagnola x Friesian and Piedmontese x Friesian steers fed four diets for 40 days before slaughter as follows: *ad libitum* silage with restricted access to a barley-based concentrate (1); *ad libitum* silage with restricted access to a barley-based concentrate and a vitamin E supplement (2000 I.U./day) (2); restricted access to silage with *ad libitum* concentrate (3); restricted access to silage with *ad libitum* concentrate and a vitamin E supplement (2000 I.U./day) (4). Samples were vacuum packaged and stored at -20°C for 4 months prior to analysis. The muscle vitamin E (α-tocopherol) content was determined by HPLC.

Packaging. *M. biceps femoris* samples were thawed at 4°C and minced. Portions of the minced muscle (50 g) were placed in gas impermeable polyvinylchloride bags, evacuated and flushed with 80 % O_2:20 % CO_2 using a Webomatic vacuum packaging system equipped with a gas mixer (Witt Gase Technik). For comparison with the MAP samples, 50 g portions of selected samples were stored in air. All samples were stored for up to 8 days at 4°C.

Colour determination. Colour measurements were made at 2 day intervals on the samples stored at 4°C in the modified atmosphere packs. An aqueous extract containing the myoglobin component was prepared from the meat samples following the procedure of Warriss (1979). Oxymyoglobin content, expressed as a percentage of the total myoglobin, was determined spectrophotometrically following the method of Krzywicki (1982). Surface redness (Hunter 'a' value) was determined using a Minolta CR-300 colorimeter.

Lipid oxidation. Lipid oxidation was measured by the 2-thiobarbituric acid method of Siu and Draper (1978) and results were expressed as 2-thiobarbituric acid reactive substances (TBARS).

RESULTS AND DISCUSSION

Inter-animal variation in *M. biceps femoris* vitamin E levels was such that there was no clear effect of dietary treatment on vitamin E content. Thus, muscle samples were grouped by vitamin E level into 4 groups with mean values ranging from 2.5 to 5.6 mg α -tocopherol/kg muscle (Table 1).

Initial (day 0) and day 2 mean values for oxymyoglobin content were not significantly different between groups (Table 1). However, after 4, 6 and 8 days of storage at 4°C the minced beef from the animals with the low muscle vitamin E content (group A) had significantly less oxymyoglobin than the minced beef from the other groups. After 8 days at 4°C in the high oxygen packs, oxymyoglobin represented ~8 and ~48 % of the total myoglobin in the low (group A) and high (group D) vitamin E groups, respectively. The results demonstrate that the extension in colour shelf-life of minced beef obtainable in high oxygen packs is dependent on the muscle vitamin E level.

A comparison of the surface redness of beef packed in air and in a high oxygen pack clearly demonstrates the advantage of high oxygen packaging in increasing redness and prolonging colour shelf-life provided there is sufficient vitamin E to minimise oxymyoglobin oxidation (Figure 1). However, in low vitamin E beef, the rate of discoloration is faster in a high oxygen pack compared to packaging in air.

The protective effect of vitamin E on colour is most likely mediated through its role as a lipid antioxidant (Table 3). Initial (day 0) values for lipid oxidation (TBARS) were not significantly different between groups. After, 2, 4, 6 and 8 days of storage at 4°C, however, lipid oxidation was significantly higher in the low vitamin E group (group A) compared to the other groups. The results support the contention that lipid oxidation is an important contributor to discoloration in beef (Renerre, 1990; Anton et al., 1991; O'Grady et al., 1996).

CONCLUSION

The effect of muscle vitamin E on fresh beef stored aerobically is well established (Faustman et al., 1989; Arnold et al., 1993, Sherbeck et al., 1995). In the present study, the role of vitamin E as a protective agent for oxymyglobin following a number of stress-inducing treatments: freezing, mincing and storage in high oxygen packs was demonstrated. The results suggest that packaging minced beef in high oxygen packs can be detrimental to colour if muscle vitamin E is insufficient to control lipid oxidation.

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Table 1. Effect of muscle vitamin E level on the oxymyoglobin content of minced *M biceps femoris* stored in a modified atmosphere, 80%O_2 : 20%CO_2

Group	Vitamin E, mg/kg		Oxymyoglobin, % of total myoglobin				
			Storage time at 4°C, days				
	Range	Mean	0	2	4	6	8
A	2.2 - 2.4	2.5 ± 0.1^{a}	68.0 ± 3.6^{a}	63.4 ± 1.7^{a}	53.6 ± 7.5^{b}	35.6 ± 8.8^{b}	8.2 ± 3.8^{b}
B	2.8 - 3.6	3.3 ± 0.4^{ab}	71.6 ± 4.4^{a}	67.4 ± 5.6^{a}	64.3 ± 0.2^{a}	58.2 ± 1.6^{a}	45.2 ± 11.7^{a}
C	3.6 - 4.2	3.9 ± 0.4^{b}	72.5 ± 2.5^{a}	69.6 ± 2.8^{a}	67.9 ± 2.8^{a}	59.5 ± 1.3^{a}	51.8 ± 2.5^{a}
D	4.9 - 6.2	5.5 ± 0.9^{c}	67.6 ± 0.6^{a}	66.8 ± 1.0^{a}	68.2 ± 0.0^{a}	57.4 ± 2.0^{a}	47.9 ± 0.9^{a}

a,b,c Mean ± standard deviation. Values in the same column bearing different superscripts are significantly different, $P < 0.05$

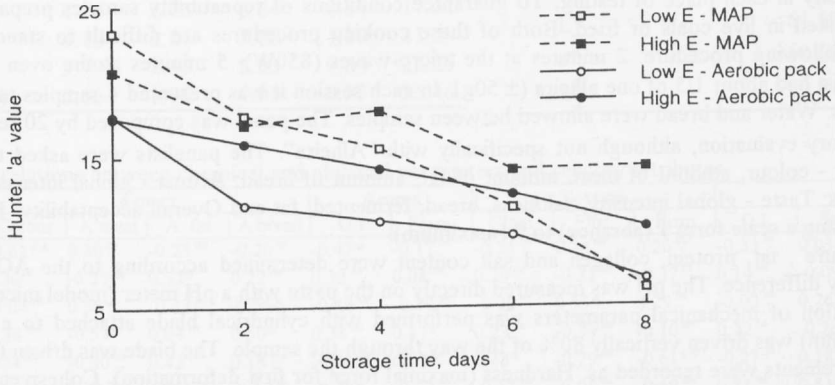

Figure 1. Effect of muscle vitamin E level (low vs high) and packaging (aerobic vs MAP) on redness (Hunter 'a' values) of minced *M. biceps femoris* stored at 4°C.

Table 2. Effect of muscle vitamin E level (Groups A - D) on lipid oxidation (TBARS) in minced *M biceps femoris* stored in a modified atmosphere, 80%O_2 : 20%CO_2.

Group	Storage time at 4°C, days				
	0	2	4	6	8
A	$0.32 \pm 0.11^{\dagger a}$	1.63 ± 0.29^{a}	3.32 ± 0.80^{a}	5.14 ± 1.35^{a}	7.86 ± 2.63^{a}
B	0.12 ± 0.11^{bc}	0.65 ± 0.53^{b}	1.09 ± 0.71^{b}	1.65 ± 1.27^{b}	1.96 ± 1.54^{b}
C	0.16 ± 0.09^{ac}	0.34 ± 0.07^{b}	0.59 ± 0.32^{b}	0.72 ± 0.45^{b}	0.84 ± 0.53^{b}
D	0.23 ± 0.05^{ab}	0.25 ± 0.04^{b}	0.31 ± 0.08^{b}	0.39 ± 0.22^{b}	0.43 ± 0.16^{b}

† Mean TBARS ± standard deviation. a,b,c Values in the same column bearing different superscripts are significantly different, $P < 0.05$