VITAMIN E IMPROVES CASE LIFE OF BEEF AFTER EXTENDED STORAGE IN CARBON DIOXIDE

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BACKGROUND

Research with beef cattle has shown that feeding vitamin E in finishing diets can elevate ∝-tocopherol in subprimal (Sherbeck *et al.*, 1995) and retail cuts (Morgan *et al.*, 1993). The result was decreased surface discolouration, a 64 to 88% reduction in product that had to be "marked-down" and a 2 to 3 day extension of retail case life. Increased colour case life has been attributed to a delay in oxymyoglobin oxidation mediated by ∝-tocopherol (Chan *et al.*, 1996).

Despite the overwhelming data on improvements to beef colour stability, there are few published reports of the effects of dietary vitamin E upon beef storage for periods of time required for sea transport, distribution and display in remote export markets. Most studies are limited to 2 to 4 weeks in modified atmospheres and the results are contradictory (Kerry *et al.*, 1996; Allen *et al.*, 1996).

The objective of the current research was to investigate the effects of vitamin E supplementation on beef steak colour stability and case life following extended periods of subprimal storage in a controlled atmosphere containing 100% CO_2 (Gill, 1989).

METHODS

Vitamin E Supplementation. Two feeding treatments of 20 steers each (Charolais x Maine Anjou) were compared: A control diet of 50% barley silage plus 50% barley with pelleted concentrate and the same diet supplemented with 1000 IU of vitamin E/animal/day. Cattle were fed for 100 days, slaughtered in a research abattoir and carcass ∝-tocopherol content determined in the *M. sternomandibularis* muscle and the *Longissimus thoracis* muscle using the HPLC method of Asghar *et al.* (1991).

Carcass and Muscle Quality. Procedures for determining carcass and muscle quality attributes have been described in detail (Greer and Jones, 1997). Shear values, ultimate pH and drip loss were determined for the *Longissimus lumborum* (LL) muscle or LL steaks.

Packaging. At 24 h postmortem the *Longissimus thoracis* (LT) muscles were packaged in an atmosphere containing 2.5 L of CO_2/kg of meat and packaged using a Captron III packaging system to give residual O_2 levels of <300 ppm. At intervals during storage at 2°C for 77 days, LT muscles were examined for anaerobic bacteria (MRS medium) and then cut into LT steaks. Steaks were wrapped in an oxygen permeable, polyvinyl chloride film (8000 cc/m^2/24h) and placed in a horizontal, retail cabinet. Steaks were evaluated during display for subjective and objective colour and aerobic bacterial growth (Plate Count Agar).

Sensory Evaluation. A 5-member sensory panel was used to evaluate the retail appearance of LT steaks using a 7-point hedonic scale. Case life was quantified by assuming rejection would occur at a point mid-point on the scale.

Colour. Reflectance spectrophotometry (MacBeth spectrophotometer) was used to calculate surface metmyoglobin concentration (Krzywicki, 1979) as well as C.I.E., a* values. All data were analyzed by analysis of variance using the General Linear Models procedure of the Statistical Analysis System (SAS).

RESULTS AND DISCUSSION

Supplementation with vitamin E produced a highly significant ($p<0.0001$) increase in the ∝-tocopherol content from 2.9μ/g in control carcasses to 5.2 μg/g in carcasses from animals fed vitamin E. These results are comparable to published values for cattle subjected to similar feeding regimes and exceed that proposed as necessary (3.3 μ/g) to promote colour stability in beef (Arnold *et al.*, 1993a).

In accordance with published results (Arnold *et al.*, 1993a), dietary vitamin E was without significant effect upon performance, carcass characteristics or meat quality. Thus there was no significant ($P<0.05$) feeding treatment effects on weight gain, carcass weight, cooler shrinkage, grade, ultimate pH, drip loss or shear values.

The average values of ∝-tocopherol in LT muscle during CO_2 storage was 2.3 μ/g in control muscles and 4.2 μ/g in LT muscles from vitamin E fed animals and there were no significant changes for up to 77 days of CO_2 storage. These values exceed the threshold concentration (4 μ/g) reported necessary for a maximum reduction in metmyoglobin concentration (Chan *et al.*, 1996) and the rate of metmyoglobin accumulation was reduced in LT steaks from vitamin E fed cattle (Table 1).

Sensory assessment of beef discolouration has been reported to correlate well with a* values (Chan *et al.*, 1995). Current data show that dietary vitamin E could result in higher a* values (Table 2) for LT steaks during retail display after CO_2 storage of LT muscle for 42 and 63 days ($P<0.05$). At these times colour case life was extended from 2.7 to 5.4 days and from 2.4 to 4.0 days, respectively (Table 3).

When LT muscle storage was extended to 77 days, no significant treatment effects were found ($P>0.05$). In contrast, to present results, Allen and coworkers (1996) were unable to demonstrate vitamin E treatment effects in the case life of retail ready steaks after storage in a master pack for up to 4 weeks in an atmosphere containing 50% CO_2 and oxygen scavengers.

Vitamin E did not effect the total anaerobic population of bacteria during LT muscle storage in CO_2 nor did it effect the population of total aerobes on LT steaks throughout retail display. Other researchers have found indigenous microbial populations on beef were unaffected by vitamin E supplementation (Arnold *et al.*, 1993b).

CONCLUSIONS

Dietary supplementation with vitamin E can be utilized in conjunction with controlled atmosphere packaging in 100% CO_2 to maintain the colour stability of beef for extended periods. Storage of subprimal beef cuts for periods sufficient to penetrate remote export markets (9 weeks) with improved aerobic case life after pack opening is feasible.

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Table 1. **The Effect of Vitamin E, CO_2 Storage and Retail Display on % Metmyoglobin[1]**

Steak Display (days)	LT Storage in CO_2 (days)					
	0		42		63	
	Control	Vit E	Control	Vit E	Control	Vit E
0						
2	13.1[a]	1.1[a]	0[a]	0[a]	1.9[a]	0[a]
4	23.8[a]	10.6[a]	3.1[a]	1.2[a]	15.1[a]	9.6[a]
6	36.3[a]	25.2[a]	21.6[a]	3.5[a]	59.4[a]	18.2[b]
	36.2[a]	17.2[b]	55.1[a]	9.8[b]	93.6[a]	39.5[b]

[1]Steaks were cut from *Longissimus thoracis* (LT) muscles after CO_2 storage at 2°C and displayed in a retail cabinet. Data are means of 8 steaks on each display day for each treatment.
[2]Means in the same row within a CO_2 storage time bearing a different superscript are different ($P<0.05$).

Table 2. **The Effect of Vitamin E, CO_2 Storage and Retail Display on a* Values[1]**

Steak Display (days)	LT Storage in CO_2 (days)					
	0		42		63	
	Control	Vit E	Control	Vit E	Control	Vit E
0						
2	11.4[a]	13.5[a]	17.6[a]	17.4[a]	16.9[a]	17.3[a]
4	12.5[a]	14.7[a]	16.4[a]	16.6[a]	13.8[a]	14.8[a]
6	11.0[a]	12.2[a]	12.9[a]	16.2[b]	9.1[a]	13.4[b]
	11.2[a]	14.0[b]	10.4[a]	15.7[b]	5.6[a]	10.9[b]

[1]Steaks were cut from *Longissimus thoracis* (LT) muscles after CO_2 storage at 2°C and displayed in a retail cabinet. Data are means of 8 steaks on each display day for each treatment.
[2]Means in the same row within a CO_2 storage time bearing a different superscript are different ($P<0.05$).

Table 3. **The Effect of Vitamin E and CO_2 Storage on the Colour Case Life of Beef Steaks[1]**

LT[2] Storage Time in CO_2 (days)	Steak Case Life (days)	
	Control	Vit E
0	5.2[a]	6.2[a]
42	2.7[a]	5.4[b]
63	2.4[a]	4.0[b]

[1]Data are means for 8 rib-eye steaks/treatment/storage interval.
[2]*Longissimus thoracis.*
Means in the same column bearing a different superscript are different ($P<0.05$).