EFFECT OF DIETARY VITAMIN E ON MICROBIAL GROWTH AND DISCOLORATION OF BEEF

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SUMMARY

This study evaluated the effect of vitamin E supplementation on beef color stability and microbial growth through objective and subjective studies. Holstein steers were fed diets supplemented with dl-α-tocopheryl acetate at dosages of 0, 500 and 2000 mg/head/day. Beef samples prepared from longissimus muscle were (1) stored at 4°C; (2) subjected to 25°C for 24 hr. with subsequent storage at 4°C; or (3) inoculated with a fluorescent pseudomonad culture and stored at 4°C. Surface metmyoglobin percentage and microbial growth on beef were measured spectrophotometrically and by total aerobic plate count, respectively. Beef supplemented with vitamin E showed less surface metmyoglobin accumulation than controls; no differences in bacterial growth were observed among the 3 treatments. Sensory evaluation showed that vitamin E supplementation improved visual acceptance of beef steaks but did not affect olfactory assessment of meat quality. Results demonstrated that overall quality of beef steaks was increased by vitamin E supplementation.

Introduction

The appearance of meat, especially its color, has been used by consumers as an important indicator for meat quality. Dietary vitamin E improved color and lipid stability and thus the shelf-life of beef and pork products (Asghar et al., 1991; Faustman et al., 1989; Lanari et al., 1993). Microbial spoilage, however, is a more appropriate assessment of quality than meat color. While vitamin E supplementation has the potential to improve the economic return by reducing conversion discounts and discards of meat products caused by discoloration, microbial response to meat with elevated vitamin E needs to be addressed. The objective of this research was to conduct a pilot study on the effect of vitamin E supplementation on beef color stability and microbial growth through objective and subjective evaluation.

Materials and Methods

Meat samples were obtained from 6 Holstein steers fed a 90% corn-plus-supplement/10% corn silage diet. Two animals per treatment were supplemented with dl-α-tocopheryl acetate at a dosage of 0 (E-0), 500 (E-500) and 2000 (E-2000) mg/head/day for 126 days. Longissimus muscles were removed at 24 hr postmortem, vacuum-packed and stored at 4°C for 14 days.

Non-abuse and Temperature Abuse Studies. Beef cores (12 cm^2 x 1 cm thick) were removed from loins aged for 14 days at 4°C, placed on fiberboard trays and overwrapped with oxygen-permeable PVC film. One set of beef cores was stored at 4°C (non-abused) for a period of 12 days. The other set of beef cores was subjected to 25°C storage (temperature-abused) for 24 hr. and subsequently stored at 4°C for a period of 12 days. Surface metmyoglobin of beef cores was determined spectrophotometrically with a diffuse integrating sphere (Stewart et al., 1965) on alternate days. Barium sulfate was used as a reference blank. Immediately after surface metmyoglobin determination, beef cores were analyzed for total microbial load. Beef cores were placed in a sterile stomacher bag with 100 ml sterile peptone water (0.1%) and homogenized for 60 sec. (Stomacher, 400 Mark II). Serial dilutions were applied to plate count agar (PCA, Difco) and incubated at 25°C for 48 hr. (Steinbrugge and Maxcy, 1988).

Challenge studies. Beef cores (12 cm^2 x 1 cm thick) were removed from loins aged for 30 days at 4°C and inoculated with a fluorescent pseudomonad culture (Faustman et al., 1990) at concentrations of 10^6 CFU/cm^2. The treated beef cores were placed on fiberboard trays, overwrapped with oxygen-permeable PVC film and subsequently stored at 4°C for 3 days. Surface metmyoglobin percentage and bacterial load of beef cores were determined as described above.

Sensory Studies. A single day of sensory evaluation was used to avoid scheduling conflicts. Thus, in order to obtain beef steaks with different microbial loads, beef steaks (2 cm thick) were cut from loins and stored at 4°C for 14, 11, 8 and 4 days; and 2 hours prior to evaluation. For each time point at which steaks were cut in advance of the sensory evaluation date, primals were re-vacuum packed. Beef steaks were wrapped as described above. Nine panelists were requested to evaluate the visual quality (discoloration, appearance acceptance), olfactory quality (spoilage), overall acceptance of the beef steaks, and to estimate the percentage surface discoloration. Objective color analysis of beef steaks was performed on the day of sensory evaluation by a Minolta Chromameter CR-200; a^* values were recorded from four different locations across the beef surface. Beef cores (12 cm^2 x 2 cm thick) were then removed from the center of steaks and analyzed for total aerobic plate count.

Results and Discussion

Surface metmyoglobin increased on meat cores stored at 4°C over the storage period of 12 days (Fig. 1a). No difference in surface metmyoglobin accumulation was observed between treatments during the first 4 days storage. When stored for more than 6 days, E-0 treated beef cores showed higher surface metmyoglobin accumulation than E-500 and E-2000. No difference in total microbial growth was found in among the three treatments at any time period (Fig. 1b). Temperature abuse of beef cores substantially increased metmyoglobin formation and total microbial growth on beef core surfaces (Fig. 2a & 2b) when compared with their non-abused counterparts (Fig. 1). Over the subsequent storage at 4°C for 8 days, surface metmyoglobin accumulation in abused samples was higher in E-0 than E-500 and E-2000; E-0, E-500 and E-2000 treated beef cores had similar bacterial growth over 12 days storage (Fig. 2b). These data suggest that vitamin E supplementation decreased oxymyoglobin oxidation on beef surfaces under normal refrigerated and elevated temperature conditions. However, elevated vitamin E in beef had no effect on microbial growth.

Accelerated oxymyoglobin oxidation was achieved by inoculation of beef surfaces with a fluorescent pseudomonad culture at levels of 10^6 CFU/cm^2 when compared with controls (no pseudomonad inoculation) over 3 days storage at 4°C (Table 1). This may be due to reduction of oxygen tension by growing bacteria which favors oxymyoglobin oxidation (Robach and Costilow, 1961). When compared with E-0 controls, E-500 and E-2000 supplementation decreased surface metmyoglobin accumulation by 27.9% and 69.4%, respectively, for inoculated beef cores stored at 4°C for 3 days (Table 1). This further confirmed that vitamin E supplementation was effective in retarding metmyoglobin formation even under elevated bacterial levels.

Sensory analysis was performed to evaluate the effect of vitamin E treatment on consumer perception of beef steak quality. Redness (a^* value) of beef loin steaks of E-0, E-500 and E-2000 treatments decreased over the 14 day storage period (Fig. 3a). Decrease in redness was greater for E-0 followed by E-500 and E-2000. This result was supported by surface discoloration as judged by panelists (Fig. 3b). Additional sensory responses are summarized in Table 2. On day 0, all steaks were considered of normal color and had acceptable appearance and thus, no treatment effect was evident on day 0. When steaks were stored at 4°C for 6 days, more panelists considered E-0 treated steaks discolored and of unacceptable appearance than E-500 or E-2000. At 12 and 14 days storage, essentially all steaks were considered discolored to some extent by panelists. However, steak appearance was still acceptable to some extent and followed the order E-2000 > E-500 > E-0. This suggests that dietary vitamin E increased red color stability in beef and improved visual acceptance of beef steaks.

Meat spoilage is a result of bacterial growth (Jay, 1972). Total aerobic microbial growth on beef steaks from E-0, E-500 and E-2000 treatments showed no difference ($p > 0.05$) during 14 days storage at 4°C (Fig. 3c). Sensory evaluation indicated that the olfactory assessment of beef steaks was similar for E-0, E-500 and E-2000 treated steaks (Table 2). Therefore, vitamin E supplementation did not affect microbial growth on beef steaks and did not influence consumer ability to assess beef spoilage.

Panelists also judged the overall quality of beef steaks based on visual and olfactory assessment (Table 2). During the early storage period, panelists did not discriminate between vitamin E treatments for overall quality. When steaks were stored up to 6 days at 4°C, panelists favored overall quality of E-2000 and E-500 treated steaks more than E-0, presumably based on higher acceptance of visual quality of E-treated steaks. When olfactory quality of beef steaks was unacceptable, panelists discriminated against all steaks regardless of appearance or treatment.

Conclusion

Vitamin E supplementation of Holstein steers at levels of 500 and 2000 mg/head/day decreased surface oxymyoglobin oxidation of beef under conditions of pseudomonad culture inoculation, temperature abuse at 25°C for 24 hr., and normal refrigerated storage at 4°C. Vitamin E supplementation also increased red color stability of beef steaks and visual acceptance by panelists. No significant effect was observed for vitamin E supplementation on microbial growth of beef or olfactory assessment by panelists.

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