QUALITY AND SHELF-LIFE OF BEEF FROM ANIMALS FED SUPPLEMENTAL VITAMIN E

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SUMMARY

Studies involving feeding supplemental levels of vitamin E to steers/heifers revealed reduced rates of lipid oxidation; reduced rate of muscle and fat discoloration; extended meat color acceptability; and similar rates of growth of total aerobic mesophilic bacteria, total coliforms, *Listeria monocytogenes* and *Escherichia coli* O157:H7 inoculated in the meat that was displayed at 4°C or 12°C. Although rates of increases in microorganisms were similar, meat from animals fed supplemental vitamin E should be refrigerated and treated as perishable because the treatment improved visual appearance but did not decrease microbial growth.

Introduction

Faustman et al. (1989a,b) and Arnold et al. (1993) have demonstrated that feeding supplemental vitamin E to beef cattle and other animals improves the caselife of the resulting meat. Levels of vitamin E and time of supplementation have ranged between 300-3,000 IU/day for 30-300 days. The level of alpha-tocopherol needed for tissue stability is 3.0-3.7 μg/g (Faustman et al., 1989a; Smith et al., 1994). Supplementation of diets with vitamin E did not affect feedlot average daily gain, feed conversion efficiency, carcass weight, marbling score, USDA quality grade or ribeye area (Arnold et al., 1993). Extension of shelf life by maintenance of acceptable meat color enhances merchandising, retail display, and shipment of product to distant markets. However, as the visual shelflife of a product is prolonged, psychrotrophic pathogenic bacteria may develop without deteriorative changes to warn the consumer of product spoilage. It is unknown whether inhibition of lipid oxidation in vitamin E treated meat will allow for better proliferation of pathogenic bacteria during storage of such meat. Thus, there is a need to determine whether such shelflife-prolonging treatments have an effect on growth of pathogenic bacteria. These concerns become especially important after the major outbreak of *Escherichia coli* O157:H7 in ground beef (Sofos and Smith, 1993). Several studies have examined providing feedlot cattle with supplemental levels of vitamin E and the effects of this practice on the chemical and sensory quality, microbial growth and economics of the resulting meat. The objective of this paper is to present data indicating how vitamin E affects quality and shelflife of the resulting beef.

Materials and Methods

Our studies have involved feeding supplemental vitamin E (alpha-tocopheryl acetate; Hoffman La Roche, Inc., Nutley, NJ) levels (0-2000 IU per head per day) in conventional finishing diets to crossbred feedlot steers/heifers for 40-123 days. After slaughter and cutting, the retail products were overwrapped in oxygen-permeable, polyvinylchloride packaging film (1000-1050 ml O_2/645 cm^2/24 hr) and placed under retail display conditions (1-4°C or 12°C) of cool-white fluorescent lighting (350-750) lux). The meat was visually evaluated for lean muscle color (8=extremely bright cherry-red; 1=very dark red), percent discoloration (7=no surface discoloration; 1=total surface discoloration) and overall appearance (8=extremely desirable; 1=extremely undesirable). On display days one and seven, a 10 g muscle sample was evaluated for extent of lipid oxidation, which was measured with the thiobarbituric acid (TBA) test involving use of 5% (wv) aqueous trichloroacetic acid (Mallincrodt, Paris, KY) as the extraction solvent. For evaluation of microbial growth, ground beef patties were inoculated with a composite inoculum of five strains of *Listeria monocytogenes*, or a composite inoculum of three strains of *Escherichia coli* O157:H7. Additional patties were inoculated with sterile 0.1% peptone water to serve as controls. The inoculum was spread on the patties with a sterile bent glass rod. Triplicate samples (patties) from each type of inoculum and level of vitamin E meat, as well as triplicate control samples were analyzed for total plate counts, coliforms, *E. coli* and *L. monocytogenes* after inoculation and storage at 4°C or 12°C.

Results and Discussion

Feeding vitamin E to feedlot steers/heifers resulted in meat cuts with alpha-tocopherol levels exceeding 4.0 µg/g of muscle compared to 2.5-3.5 µg/g for the controls. The pH of meat from animals fed diets with different levels of vitamin E was similar. The pH ranges of animals fed 0, 1000 and 2000 IU supplemental vitamin E were 5.74-6.08, 3.68-5.92, and 5.68-5.91, respectively. The color of the lean of ground beef from feedlot animals fed 500 IU vitamin E per head per day for 123 days remained light-red for a longer period of time than control product, with no supplemental vitamin E in the diet (data not shown). The results also indicated that percent discoloration of T-bone steaks displayed at 1-2°C increased significantly ($P<0.05$) faster in the control compared to the vitamin E (500 IU) treatment (Table 1). Overall appearance of ground beef patties displayed aerobically at 4°C was also affected by level of vitamin E in the diet of feedlot cattle (Table 2). The treatment from animals with 0 IU of supplemental vitamin E was very undesirable in visual appearance after 4 days of display at 4°C. The treatments of ground beef patties from animals fed 1000 or 2000 IU of vitamin E reached undesirable scores after 6 days of display at 4°C. These results demonstrate clearly the dramatic effect of supplemental dietary vitamin E on the color and appearance of beef cuts from feedlot steers or heifers. These effects are important in beef retail operations of the United States because the meat that maintains its color and appearance does not have to undergo a reduction in price (discounting) for sale before the sell-by date that appears on the label. This is demonstrated by the results of Table 3, which show that a much greater percentage of packages from control meat had to be discounted at a supermarket compared to vitamin E meat. Supplementation of feedlot cattle diets with vitamin E also inhibits lipid oxidation and product rancidity (Table 4). Growth of total aerobic bacteria in ground beef from animals fed different vitamin E levels (0, 1500, 2000 IU) was similar among treatments during aerobic display at 4°C (Table 5). Although there were some statistically ($P<0.25$) significant differences, their practical importance is questionable. Total coliform bacteria did not multiply in meat from any vitamin E treatment at 4°C (data not shown). Supplementation of vitamin E in the diet of feedlot cattle had no major effect on pathogenic bacteria such as *E. coli* O157:H7 or *L. monocytogenes*. Growth rates of *E. coli* O157:H7 at 12°C were similar in ground beef from diets of 0, 1000 and 2000 IU (Table 6). Growth of the psychrotrophic pathogen *L. monocytogenes* was only slight at 4°C, but similar among ground beef patties from different vitamin E treatments (Table 7).

Conclusions

Feeding supplemental vitamin E to feedlot cattle results in meat that maintains its visual appearance and chemical sensory qualities for a period of time that is longer than the control. This is important because it reduces discounts that supermarkets have to offer for meat as its appearance deteriorates. In general, feedlot studies have demonstrated that supplementation of feedlot diets for cattle with 500-1000 IU of vitamin E per head and day for approximately 100 days before slaughter enhances beef quality. Growth rates of spoilage bacteria and of the pathogens *E. coli* O157:H7 and *L. monocytogenes* are similar in meat from animals fed vitamin E diets and controls. However, fresh meat should be kept refrigerated, treated as perishable and the sell-by date not be extended because the vitamin E treatment improves visual appearance but does not inhibit microbial growth.

References

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Tables

Table 1. Percent discoloration of T-bone steaks from animals fed diets with different levels of vitamin E. The steaks were displayed aerobically at 1-2°C.

Table 2. Overall appearance of ground beef patties from animals fed diets with different levels of vitamin E. The patties were displayed aerobically at 4°C.

Table 3. Percent of items discounted due to color deterioration before the sell-by date at the retail supermarket of beef from animals fed diets with different levels of vitamin E.

Table 4. Thiobarbituric acid (TBA) numbers (mg maloaldehyde per kg muscle) of ground chuck from animals fed diets with different levels of vitamin E. The ground beef was displayed aerobically at 1-2°C.

Table 5. Total aerobic plate counts (log CFU/g) in ground beef batties from animals fed diets with different levels of vitamin E. The patties were displayed at 4°C.

Table 6. Counts (log MPN/g of *Escherichia coli* O157:H7 in inoculated ground beef patties from animals fed diets with different levels of vitamin E. The patties were displayed aerobically at 12°C.

Table 7. Counts (log CFU/g) of *Listeria monocytogenes* in inoculated ground beef patties from animals fed diets with different levels of vitamin E. The patties were displayed at 4°C.