IMPROVEMENT OF PIGMENT AND LIPID STABILITY IN GROUND AND SLICED BEEF LONGISSIMUS WITH DIETARY VITAMIN E SUPPLEMENTATION

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S-IVA.46

SUMMARY

Effects of dietary vitamin E supplementation on pigment and lipid stability in ground and sliced beef longissimus were studied. Dietary vitamin E supplementation resulted in small increases of metmyoglobin percentages in ground and sliced beef and very slight increases of 2-thiobarbituric acid reactive substances values during 9 days for ground and 14 days for sliced beef of display compared to the control ground and sliced beef.

Introduction

Metmyoglobin formation and lipid oxidation are the most important problems in maintaining a stable display of retail beef. When the color of ground or sliced beef changes from bright red (oxymyoglobin) to brown (metmyoglobin), consumers prefer not to purchase the meat. Therefore, pigment and lipid stability in retail beef are very important for both beef retailers and consumers.

Dietary supplementation of vitamin E was shown to decrease pigment or lipid oxidation in meat from poultry (Marusich et al., 1975), pigs (Tsai et al., 1978) and cattle (Faustman et al., 1989).

The purpose of this work was to study the effects of dietary vitamin E supplementation on pigment and lipid stability in ground and sliced beef longissimus.

Materials and Methods

A control diet was fed to nine Holstein (80 IU vitamin E/day) and nine beef (60 IU/day) steers and a supplemented diet was fed to nine Holstein (1460 IU/day) and eight beef (1190 IU/day) steers. Steers were slaughtered in 3 groups at 3-wk intervals (211, 232 and 252 days). The left strip loin from each steer was removed 24 hr after slaughter, vacuum-packaged and stored for an additional 6 days at 4°C. Ground beef samples (20 g miniature patties) were prepared from longissimus lumborum (LL) of six control and six supplemented Holstein steers of 232 and 252 days-slaughter groups (Mitsumoto et al., 1993). Sliced beef samples (1 cm thick and 5 cm diameter pieces) were prepared from LL muscles of all steers (Arnold et al., 1993). The ground and sliced samples were over-wrapped with PVC film and displayed under fluorescent lights at 4°C for 9 and 14 days, respectively.

Vitamin E analysis

The α-tocopherol concentrations in LL muscles were measured by the method of Arnold et al. (1993).

Metmyoglobin analysis

Surface metmyoglobin percentages were determined by reflectance spectrophotometry (Stewart et al., 1965) at 1, 3, 5, 7 and 9 days for ground beef and 2, 6, 10 and 14 days for sliced beef.

Lipid oxidation analysis

2-Thiobarbituric acid reactive substances (TBARS) were measured by the method of Witte et al. (1970) at 1, 3, 5 and 7 days for ground beef and 2, 6, 10 and 14 days for sliced beef. Trichloroacetic acid

solution (20% w/v) was used for the extraction blending. TBARS values were expressed as mg malonaldehyde (MDA) / kg muscle.

Statistical analyses

Data were analyzed by the General Linear Models procedure of SAS (1985).

Results and Discussion

The average α-tocopherol concentration in LL muscles was increased ($P<.01$) by vitamin E supplementation (control Holstein steers, 1.2 mg/kg; supplemented Holstein steers, 6.2 mg/kg; control beef steers, 1.0 mg/kg; supplemented beef steers, 7.2 mg/kg).

Dietary vitamin E supplementation resulted in small increases of metmyoglobin percentages in ground and sliced beef (from 6.8% to 40.4%, and from 6.4% to 35.7%, respectively; Fig. 1) and very slight increases of TBARS values (from .15 to .58, and from .07 to .15, respectively; Fig. 2) during 9 days for ground and 14 days for sliced beef of display compared to the control ground and sliced beef (metmyoglobin percentages, from 19.0% to 86.8%, and from 9.0% to 78.7% in Fig. 1; TBARS values, from 2.02 to 6.91, and from .64 to 6.69 in Fig. 2, respectively).

Greene et al. (1971) reported that consumers would reject beef containing over 30% to 40% metmyoglobin. In this study 30% metmyoglobin was exceeded after about day 2 and 5 in the control ground and sliced beef, respectively, and after about day 8 and 13 in vitamin E supplemented samples (Fig. 1). Hence, dietary vitamin E supplementation delayed metmyoglobin increases in ground and sliced beef for 6 and 8 days, respectively, compared to the control.

The TBARS value at each final observation day for ground and sliced beef with dietary vitamin E supplementation did not exceed the value at each initial day for the control ground and sliced beef (Fig. 2).

Vitamin E acts as an antioxidant by reacting with free radicals (Tappel, 1962). Oxidation in meat is reported to be initiated in the phospholipid-rich membranes (Buckley et al., 1989). Asghar et al. (1991) confirmed α-tocopherol deposition in the cellular membranes of pigs fed vitamin E-supplemented diets. Therefore, we suggest that dietary vitamin E was absorbed by steers and incorporated into cellular membranes. Even after the muscle was ground or sliced, the vitamin E in the membranes mainly prevented lipid oxidation by reacting with free radicals and preventing secondary pigment oxidation. Hence, the stabilities of pigment and especially lipid were improved in both ground and sliced beef with dietary vitamin E supplementation.

Conclusion

Dietary vitamin E supplementation retarded pigment oxidation and highly suppressed lipid oxidation in ground and sliced beef compared to the control. Dietary vitamin E supplementation would be an effective method for improving pigment and lipid stability in retail ground and sliced beef.

Acknowledgments

This work was supported by the College of Agricultural and Life Sciences, University of Wisconsin-Madison in cooperation with the Beef Industry Council of the National Live Stock and Meat Board, the Wisconsin Beef Council, Hoffmann-LaRoche Inc., Oscar Mayer Foods Corp. and Packerland Packing Co., Green Bay, Wisconsin. The authors acknowledge Dennis M. Heisey for statistical analyses.

References

Arnold, R.N., Scheller, K.K., Arp, S.C., Williams, S.N. and Schaefer, D.M., (1993). Dietary α-tocopheryl acetate enhances beef quality in Holstein and beef breed steers. J. Food Sci., 58: 28-33.

Asghar, A., Gray, J. I., Booren, A. M., Gomaa, E. A., Abouzied, M. M., Miller, E. R. and Buckley, D. J., (1991). Effects of supranutritional dietary vitamin E levels on subcellular deposition of α-tocopherol in the muscle and pork quality. J. Sci. Food Agric., 57: 31-41.

Buckley, D.J., Gray, J.I., Asghar, A., Price, J.F., Crackel, R.L., Booren, A.M., Pearson, A.M. and Miller, E.R., (1989). Effects of dietary antioxidants and oxidized oil on membranal lipid stability and pork product quality. J. Food Sci., 54: 1193-1197.

Faustman, C., Cassens, R.G., Schaefer, D.M., Buege, D.R., Williams, S.N. and Scheller, K.K., (1989). Improvement of pigment and lipid stability in Holstein steer beef by dietary supplementation with vitamin E. J. Food Sci., 54: 858-862.

Greene, B.E., Hsin, I. and Zipser, M.W., (1971). Retardation of oxidative color changes in raw ground beef. J. Food. Sci., 36: 940-942.

Marusich, W.L., De Ritter, E., Ogrinz, E.F., Keating, J., Mitrovic, M. and Bunnell, R.H., (1975). Effect of supplemental vitamin E in control of rancidity in poultry meat. Poult. Sci., 54: 831-844.

Mitsumoto, M., Arnold, R.N., Schaefer, D.M. and Cassens, R.G., (1993). Dietary versus post-mortem supplementation of vitamin E on pigment and lipid stability in ground beef. J. Anim. Sci., 71: 1812-1816.

SAS Institute, Inc., (1985). "SAS User's Guide: Statistics," Version 5 Ed. SAS Institute, Cary, NC.

Stewart M.R., Zipser, M.W. and Watts, B.W., (1965). The use of reflectance spectrophotometry for the assay of raw meat pigments. J. Food Sci., 30: 464-469.

Tappel, A.L., (1962). Vitamin E as the biological lipid antioxidant. Vitam. Horm., 20: 493-510.

Tsai, T.C., Wellington, G.H. and Pond, W.G., (1978). Improvement in the oxidative stability of pork by dietary supplementation of swine rations. J. Food Sci., 43: 193-196.

Witte, V.C., Krause, G.F. and Bailey, M.E., (1970). A new extraction method for determining 2-thiobarbituric acid values of pork and beef during storage. J. Food Sci., 35: 582-585.

FIGURES:

Fig. 1. Relationship of dietary vitamin E supplementation x days displayed on surface metmyoglobin percentages in ground and sliced beef longissimus. Control-ground = control ground beef; Control-sliced = control sliced beef; Dietary E-ground = ground beef with dietary vitamin E supplementation; Dietary E-sliced = sliced beef with dietary vitamin E supplementation.

Fig. 2. Relationship of dietary vitamin E supplementation x days displayed on TBARS values in ground and sliced beef longissimus. Control-ground = control ground beef; Control-sliced = control sliced beef; Dietary E-ground = ground beef with dietary vitamin E supplementation; Dietary E-sliced = sliced beef with dietary vitamin E supplementation.