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EFFECT OF ANTIOXIDANTS ON FRESH PORK SAUSAGE, AND FISH OIL FORTIFIED GROUND BEEF

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Introduction

Muscle food products comprise a major portion of the average American's diet and have the potential to contribute a substantial quantity of long chain (LC) n-3 fatty acids on a daily basis. Ollis et al. (1999) reported that canola oil and fish were the primary sources of linolenic acid and LC n-3 fatty acids in the Australian diet, respectively. However, the authors specifically noted the unexpected finding that meat products were a major source of LC n-3 polyunsaturated fatty acids (PUFAs) (i.e. 29% of total dietary contribution). Although meat is not generally considered a rich source of LC n-3 PUFAs, meat products could be an efficacious delivery medium for LC n-3 PUFA.

One potential challenge presented by increasing the PUFA of meat products, whether by dietary supplementation of the live animal or process fortification of the meat raw material, is greater susceptibility to lipid oxidation. The degree to which PUFA alterations have affected flavor has ranged from no effect (Leskanich et al., 1997) to a significant sensory detection of off-flavors (Coxon et al., 1986; O'Keefe et al., 1995). Utilization of antioxidants to minimize lipid oxidation in meat products, with or without alteration of the fatty acid profile, has been an effective means to delay off-flavor development (Crawford et al., 1976; Faustman, 1993).

Increasing the LC n-3 PUFA concentration of fresh meat products is a logical approach for delivering this nutrient in a 'functional food'. However, it is critical that the increased oxidative susceptibility expected from this processing approach is anticipated and addressed.

Objectives

To determine the suitability of antioxidant systems for ground beef fortified with stabilized fish oil vs. non-stabilized (unstabilized) fish oil, and for non-fortified fresh pork sausages.

Methodology

Preparation of Meat Products

Fresh pork sausages

Fresh boneless pork shoulder butts were ground coarsely (19.2 mm), mixed with breakfast sausage seasoning containing salt, red pepper, sage, sugar and black pepper (No.25, A.C.Legg Packing Co., Inc., Birmingham, AL), mixed with antioxidants (DL α-tocopherol, 95% liquid mixed tocopherol, BHA/BHT, rosemary extract), ground fine, and formed into patties (5 cm dia, 1.5 cm thick, 25 g). Patties were wrapped with oxygen-permeable PVC film (15,500-16,275 cm^3 O_2/m^2/24 h at 23 °C) and stored at 4°C or -18°C. Analyses were performed on patties stored fresh for 0, 2, 4 and 6 days, and frozen for 0, 3, and 6 weeks.

Controls were pork sausages only (CON) or pork sausages containing the amount of coconut oil used to deliver antioxidants (CON+COCONUT)(i.e. DL α-tocopherol, 95% liquid mixed tocopherol, BHA/BHT and rosemary extract). Treatments were DL-α-tocopherol, A–TOC (0.03%, w/w based on fat content); 95% liquid mixed tocopherol, 95MIX-TOC (0.03%, w/w based on fat content); butylated hydroxyanisole/butylated hydroxytoluene, BHA/BHT (0.02%, w/w based on fat content); rosemary extract, ROSE (0.2%, w/w).

Ground beef patties

Fresh coarse ground beef (85% lean, 15% fat), obtained locally, was mixed with fish oil and antioxidants (mixed tocopherol, ascorbyl palmitate, rosemary extract, and butylated hydroxyanisole/butylated hydroxytoluene), ground fine (5 mm) and formed into patties (5 cm dia, 1.5 cm thick, 25 g). Patties were packaged on trays with oxygen-permeable PVC film (15,500-16,275 cm^3 O_2/m^2/24 h at 23 °C) and stored at 4°C or -18°C. Analyses were performed on patties stored fresh for 0, 2, 4 and 6 days, and frozen for 0, 3, and 6 weeks.

Unstabilized fish oil (U-OIL), a refined blend of fish oil triglycerides (ROPUFA ‘30’ n-3 Food Oil) and the same product stabilized with mixed tocopherol and rosemary (S-OIL), were obtained from DSM Nutritional Products Inc. (Belvidere, NJ, USA). Controls were ground beef only (CON), ground beef containing unstabilized fish oil (U-OIL) or ground beef containing fish oil commercially stabilized with mixed tocopherol and rosemary (S-OIL). Treatments were stabilized oil with mixed tocopherol, S-OIL+TOC; stabilized oil with mixed tocopherol and rosemary extract, S-OIL+TOC+ROSE; stabilized oil with butylated hydroxyanisole/butylated hydroxytoluene (S-OIL+BHA/BHT); stabilized oil with ascorbyl palmitate (S-OIL+AP); stabilized oil with ascorbyl palmitate and mixed tocopherol (S-OIL+AP+TOC); stabilized oil with ascorbyl palmitate and rosemary extract (S-OIL+AP+ROSE); stabilized oil with ascorbyl palmitate, mixed tocopherol and rosemary extract (S-OIL+AP+TOC+ROSE). TOC was added at 0.03% (w/w based on fat content); ROSE was added at 0.2% (w/w based on fat

content); AP was added at 0.02% (w/w based on fat content); BHA/BHT was added at a maximum level of 0.02% (w/w based on fat content).

Measurement of Color and Lipid oxidation

Colorimetric values (CIE L*, a*, b*) were determined by measurement with a Minolta Chromameter (Model CR-200b, Minolta Co., Osaka, Japan) and hue angle was calculated as $\tan^{-1}$ (b*/a*)×360°/2 (Chan et al., 1996). The thiobarbituric acid (TBA) procedure of Yin et al. (1993) was used to assess lipid oxidation and reported as TBA-Reactive Substances (TBARS).

Results & Discussion

Fresh pork sausages

A decrease in a^* value and increase in hue angle are each consistent with discoloration of fresh meat. A-TOC was most effective for maintaining color stability (greater a* values, lower hue angle values) during storage at 4°C when compared to other treatments ($p<0.05$)(results not shown). While increased muscle concentrations of tocopherol have proved effective at slowing meat discoloration via dietary supplementation of beef cattle with vitamin E, the effect has not been well documented for vitamin E as an exogenous ingredient (Faustman et al., 1998).

The results for the effect of antioxidant treatments on lipid oxidation (TBARS) in fresh and frozen pork sausage patties are presented in Figure 1. In general, all antioxidant treatments were effective at minimizing lipid oxidation relative to the respective controls (CON and CON+COCONUT). There was no difference between the different antioxidants during storage at 4°C ($p>0.05$), whereas BHA/BHT was most effective at minimizing lipid oxidation during storage at -18°C when compared to A-TOC, 95MIX-TOC or ROSE ($p<0.05$).

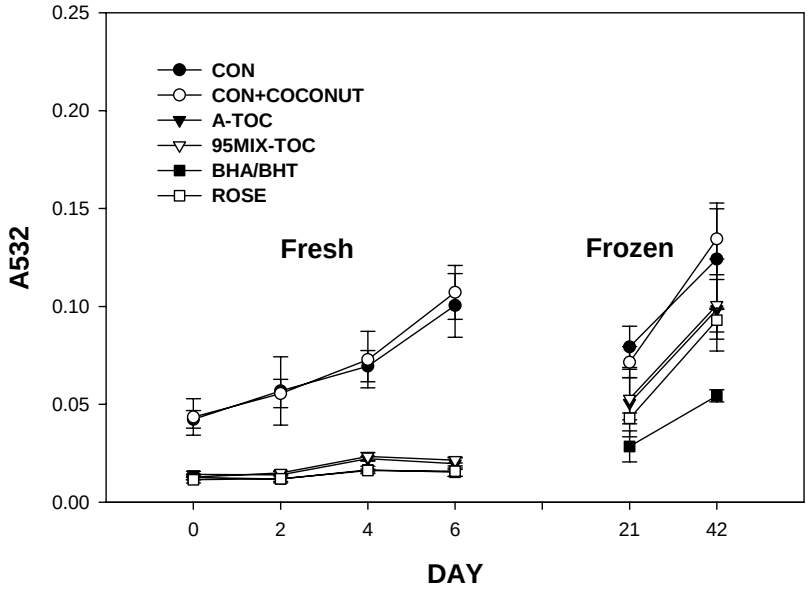

Figure 1. Changes in lipid oxidation (TBARS) of control (CON), control with coconut oil (CON+COCONUT), DL α-tocopherol (A-TOC), 95% mixed tocopherol (95MIX-TOC), BHA/BHT and rosemary extract (ROSE) treated fresh pork sausages stored at 4°C or -18°C. Standard deviation bars are indicated.

Ground beef patties

All antioxidant treatments except S-OIL+AP stabilized color when compared to controls (CON, CON+UOIL and CON+SOIL)($p<0.05$)(results not shown). There were no consistent effects of antioxidant treatments on hue angle during storage ($p>0.05$) (results not shown).

The effects of antioxidant treatments on lipid oxidation (TBARS) in fresh and frozen ground beef patties are presented in Figure 2. As expected, the lipid oxidation was considerably high in beef patties fortified with non-stabilized (unstabilized) fish oil. On the other hand, when fortified with S-OIL (ROPUFA 30 Food Oil, which is stabilized), the lipid oxidation was actually lower than the control at refrigerated conditions. The oxidation was further reduced by incorporating antioxidant systems. BHA/BHT followed by TOC + ROSE showed the greatest antioxidant effect during storage. There was no significant lipid oxidation and no effects of antioxidants were observed during frozen storage ($p>0.05$). The combination of AP, TOC and ROSE delayed lipid oxidation more effectively relative to each of these antioxidants alone. Calvert and Decker (1992) suggested that antioxidant combinations would inhibit lipid oxidation more effectively than the use of any single antioxidant, and synergism might result from the action of mixed free radical scavengers.

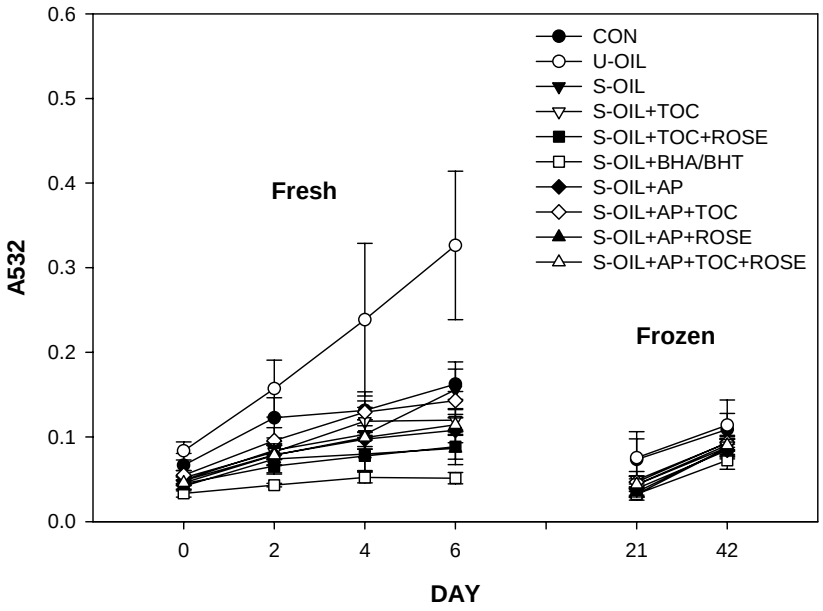

Figure 2. Lipid oxidation (TBARS) in control (CON), control with unstabilized fish oil (U-OIL), control with stabilized fish oil (S-OIL), stabilized fish oil + mixed tocopherol (S-OIL+TOC), stabilized fish oil + mixed tocopherol + rosemary (S-OIL+TOC+ROSE), stabilized fish oil + butylated hydroxyanisole/butylated hydroxytoluene (S-OIL+ BHA/BHT), stabilized fish oil + ascorbyl palmitate (S-OIL+AP), stabilized fish oil + ascorbyl palmitate + mixed tocopherol (S-OIL+AP+TOC), stabilized fish oil + ascorbyl palmitate + rosemary (S-OIL+AP+ROSE), and stabilized fish oil + ascorbyl palmitate + mixed tocopherol + rosemary (S-OIL+AP+TOC+ROSE) treated ground beef patties during storage at 4°C (fresh) or -18°C (frozen). Standard deviation bars are indicated.

Conclusions

Antioxidants of tocopherol product type were incorporated into fresh pork sausages and proved effective at minimizing lipid oxidation. A-TOC appeared most effective for stabilizing color in fresh pork sausages. Stabilized fish oil appeared to be more suitable for incorporation in ground beef patties when compared to unstabilized fish oil. An antioxidant combination containing mixed free radical scavengers (mixed tocopherols and rosemary) incorporated into LC n-3 PUFA fortified ground beef patties effectively minimized lipid oxidation.

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