ANTIOXIDATIVE EFFECTS OF AN OLEORESIN ROSEMARY IN RESTRUCTURED MEAT PRODUCTS

S.M. STOICK, S. LAI, J.I. GRAY, R.L. CRACKEL, A.M. BOOREN, D.M. SMITH AND D.J. BUCKLEY

Department of Food Science & Human Nutrition, Michigan State University, East Lansing, MI, 48824 USA

INTRODUCTION

Development of oxidative rancidity has long been recognized as a serious problem during the holding or storage of meat products for subsequent consumption (Pearson et al., 1977). Warmed-over flavor (WOF) in meat is a form of oxidative rancidity that develops within a few days in contrast to common rancidity that requires months to develop fully during freezer storage (Pearson et al., 1977). WOF is normally associated with meats that are cooked or in which the membranes are broken down by processes such as restructuring or grinding. In general, any process that disrupts the integrity of the membranes enhances development of WOF.

Comminution of raw meat both disrupts the membranal structures and incorporates oxygen into the tissue. Membrane-bound lipids consist largely of phospholipids which, because of their high degree of unsaturation are especially susceptible to lipid oxidation (Pearson et al., 1977). Grinding, chopping or emulsifying exposes these labile phospholipids not only to oxygen but also to other tissue catalysts such as enzymes, heme pigments and metal ions. Salt added during the manufacture of restructured meat products has also been shown to initiate undesirable reactions. Schwartz and Mandigo (1976) reported that increasing salt levels in flaked and formed pork produced increased thiobarbituric acid (TBA) values and decreased raw color scores. Work by Huffman et al. (1981) demonstrated that TBA values of restructured pork chops increased linearly in response to increasing salt levels.

Synthetic antioxidants such as butylated hydroxyanisole (BHA) and tertiarybutyl hydroquinone (TBHQ) have been shown to reduce lipid oxidation in restructured meat products (Chastain et al., 1982; Crackel et al., 1988) during refrigerated storage and up to 20 weeks of frozen storage. Naturally occurring antioxidants, including rosemary extracts, can also be used with considerable success to reduce rancidity development in meat products. Oleoresin rosemary (OR) contains a number of compounds such as rosmanol, carnasol, rosmaridiphenol and rosmariquinone which possess antioxidant activity similar to or greater than BHA (Houlihan and Ho, 1985). Barbut et al. (1985) demonstrated that the incorporation of OR in sensitive meat products, such as a turkey breakfast sausage prepared from a combination of hand deboned turkey meats, can substantially suppress lipid oxidation and increase product shelf life at refrigerated temperatures. Chemical and sensory analyses showed that OR was comparable to a commercial blend of BHA/BHT/citric acid in antioxidant efficacy. Korczak et al. (1988) also demonstrated a pronounced antioxidant effect for rosemary in precooked minced meat products.

The primary objective of this study was to evaluate the effectiveness of OR as an antioxidant during refrigerated and frozen storage of restructured beef steaks and chicken nuggets. A commercial OR (Kalsec Inc., Kalamazoo, MI) was tested at two levels with and without sodium tripolyphosphate (STPP). Possible

additive effects between OR and STPP were also investigated.

MATERIALS AND METHODS

Manufacture and analysis of restructured beef steaks

Three replications of seven treatments were used in this study. The treatments included salt (0.75%), salt/STPP (0.3%), 0.05% OR, 0.1% OR, 0.05% OR/STPP, 0.1% OR/STPP and TBHQ/STPP. The restructured beef steaks were manufactured using the method of Booren et al. (1981) to contain 15% fat by combining lean and fat fractions. Salt, STPP and antioxidants were added to the lean beef during the first thirty seconds of mixing. The fat fraction was added for the last three minutes of vacuum mixing. The meat was frozen in logs, then portioned into 9x1.5 cm thick steaks which were packaged in polyethylene-laminated nylon pouches.

The refrigerated study was designed to test the storage stability of cooked steaks held at 4˚C over a six-day period. The steaks were cooked to an internal temperature of 70˚C in a convection oven set at 177˚C. TBA values were measured in duplicate using the distillation method of Tarladgis et al. (1964), as modified by Crackel et al. (1988). A 12 member semi-trained sensory panel rated the samples on a six point scale for degree of warmed-over flavor. Zero corresponded to no WOF and 5 to a very strong WOF.

For the frozen study, the raw steaks were held at -20˚C for 6 months. At three month intervals, representative steaks were thawed, cooked as described above, and analyzed for TBA values and sensory scores. Steaks containing TBHQ/STPP were vacuum packaged and served as reference samples for the sensory panel.

Preparation and analysis of restructured chicken nuggets

Restructured chicken nuggets formulated to 7% fat were prepared from a combination of intact white (50%) and dark (30%) meat and mechanically deboned meat (20%) using a standard commercial procedure. Seven treatments similar to those tested for the beef steaks were included in the study. The breaded chicken nuggets were fried to an internal temperature of 76˚C in partially hydrogenated soybean oil (176˚C), immediately cooled in a freezer (-20˚C) and then packaged as for the beef steaks. The nuggets were refrigerated at 4˚C for six days and frozen at -20˚C for six months. TBA values and sensory analyses were carried out as described above. Nuggets were also fried in oil containing 0.025% and 0.05% OR and evaluated over the two storage periods.

RESULTS AND DISCUSSION

Restructured beef steaks

After six days of refrigerated storage, the control steaks (salt only) had the largest TBA values (11.3 mg malonaldehyde/kg meat) and a poor sensory score (4.3 on a scale of 0 to 5) (Table 1). Meat processed with OR but without STPP also had extremely high TBA values and poor sensory scores after six days. No significant difference was found between the salt/STPP, 0.05% OR/STPP, 0.1% OR/STPP and TBHQ/STPP treatments ($p<0.05$). All four treatments in which STPP was an integral part provided good protection against autoxidation. However, the antioxidant effect of OR was not significant during refrigerated storage of cooked beef steaks. These results generally agree with those of Barbut et al. (1985) and indicated that the main antioxidant effect was due to the presence of sodium tripolyphosphate. Results of the frozen study differed substantially from those of

the refrigerated storage study (Table 2). TBA values indicated that the effects of STPP were significant ($p<0.05$) and that there was a significant linear concentration effect of OR ($p<0.05$). No significant difference was found between the 0.1% OR/STPP treatment and the TBHQ/STPP treatment after six months of storage, indicating that OR/STPP was equally as effective as TBHQ/STPP in protecting frozen, restructured beef steaks. STPP and OR by themselves were less effective than the OR/STPP combinations. This additive effect is probably due to the different mechanisms involved. STPP functions as an antioxidant by chelating prooxidant metals such as ferrous iron in cooked meats, while the phenolic components in the OR act by interrupting the free radical chain mechanism. Sensory scores also confirm the antioxidant effectiveness of the OR/STPP combinations, although detectable levels of WOF or oxidized flavor (sensory score of 2 = slight WOF) were observed for the 0.1% OR/STPP and TBHQ/STPP treatments after six months.

Hexanal concentrations in the beef samples also increased substantially over the six month storage period (data not presented). These results again confirm the effectiveness of the OR/STPP combinations. For example, a 25-fold increase in hexanal was detected in the salt control after only three months, compared to a 4-fold increase in the OR/STPP treatments over the same storage period.

Restructured chicken nuggets

Chemical and sensory data for restructured chicken nuggets demonstrated that TBHQ, when used in combination with STPP, exhibited the best protective effect during refrigerated storage (Table 3). Both OR (0.1%) and STPP when used alone reduced the extent of salt-catalyzed lipid oxidation, although STPP was more effective than the OR over the storage period. However, the combination of OR (both levels) and STPP was very effective and demonstrated an additive antioxidant effect. This is in contrast to the results of the refrigerated study for restructured beef steaks where the main antioxidant effect was due to the presence of STPP.

Similar trends were observed for the chicken nuggets during frozen storage (Table 4). TBHQ/STPP was the most effective antioxidant combination. The additive effect between OR and STPP was again observed, although it was not as pronounced as that obtained for the refrigerated study.

Studies involving the cooking of nuggets in soybean oil containing OR and subsequent storage of the cooked nuggets under refrigerated and frozen conditions indicated no apparent beneficial effects of adding the antioxidant to the oil on the oxidative stability of the nuggets (Tables 3 and 4). These results imply that either the antioxidant principles in OR were stripped from the oil during the cooking of the nuggets or that the OR did not penetrate into the chicken meat during storage. TBA analyses were carried out with the whole nugget, i.e., breading and meat were blended together before samples were taken for analysis. It is most likely that the meat lipids would deteriorate more rapidly than the vegetable oil absorbed by the breading of the nuggets. However, the addition of OR to frying oil would probably be beneficial in stabilizing the oil in other food products such as potato chips and frozen french-fried potatoes.

CONCLUSIONS

Results of this study indicated that OR when used in combination with

STPP in cooked restructured meat products effectively inhibited lipid oxidation during refrigerated and frozen storage. Thus, the natural OR should be pursued further as a substitute for synthetic antioxidants for preserving the shelf life of restructured meats during extended storage.

ACKNOWLEDGMENTS

Michigan Agricultural Experiment Station Journal Article No. 13039. The authors gratefully acknowledge the support of these studies by a grant from the National Live Stock and Meat Board, Chicago, Illinois.

REFERENCES

Barbut, S., Josephson, D.B. & Maurer, A.J. (1985): Antioxidant properties of rosemary oleoresin in turkey sausage. J. Food Sci. 50:1356.

Booren, A.M., Mandigo, R.W., Olson,, D.G. & Jones, K.W. (1981): Effect of muscle type and mixing time on sectioned and formed beef steaks. J. Food Sci. 46:1665.

Chastain, M.F., Huffman, D.L., Hsieh, W.H. & Cordray, J.C. (1982): Antioxidants in restructured beef/pork steaks. J. Food Sci. 47:1779.

Crackel, R.L., Gray, J.I., Booren, A.M., Pearson, A.M. & Buckley, D.J. (1988a): Effect of antioxidants on lipid stability in restructured beef steaks. J. Food Sci. 53:656.

Crackel, R.L., Gray, J.I., Pearson, A.M., Booren, A.M. & Buckley, D.J. (1988b): Some further observations on the TBA test as an index of lipid oxidation in meats. Food Chem. 28:187.

Houlihan, C.M. & Ho, Co. (1985): Natural antioxidants. Chapter 6. In "Flavor Chemistry of Fats and Oils," D.B. Min and T.H. Smouse, (ed), p. 140. Amer. Oil Chem. Society, Champaign, Illinois.

Huffman, D.L., Ly, A.M. & Cordray, J.C. (1981): Effect of salt concentration and quality of restructured pork chops. J. Food Sci. 46:1563.

Korczak, J., Flaczyk, E. & Pazola, Z. (1988): Effects of spices on stability of minced meat products kept in cold storage. Fleischwirtschaft. 68:64.

Pearson, A.M., Love, J.D. & Shorland, F.B. (1977): Warmed-over flavor in meat, poultry and fish. Adv. Food Res. 23:1.

Schwartz, W.C. & Mandigo, R.W. (1976): Effect of salt, sodium tripolyphosphate and storage on restructured pork. J. Food Sci. 41:1266.

Tarladgis, B.G., Pearson, A.M. & Dugan, L.R. (1964): Chemistry of the 2-thiobarbituric acid test for determination of oxidative rancidity in foods: II. Formation of the TBA-malonaldehyde complex without acid-heat treatment. J. Sci. Food Agric. 15:602.

Table 1. Mean TBA values and sensory scores for cooked, restructured beef steaks during refrigerated storage[a,b,c]

Treatment	Day 0		Day 2		Day 4		Day 6	
	TBA	Sensory	TBA	Sensory	TBA	Sensory	TBA	Sensory
Salt	1.34	1.19	5.67	3.27	10.4	4.30	11.30	4.31
Salt/STPP	0.29	0.31	0.66	0.68	0.58	1.05	0.84	1.42
Salt/OR (0.05%)	0.76	1.06	5.30	3.26	8.65	4.43	9.73	4.00
Salt/OR (0.1%)	0.56	0.86	5.00	3.49	6.60	4.19	9.90	4.36
Salt/STPP/OR (0.05%)	0.27	0.47	0.38	0.83	0.47	1.05	0.40	1.31
Salt/STPP/OR (0.1%)	0.27	0.42	0.47	0.73	0.64	1.36	0.97	1.36
Salt/STPP/ TBHQ	0.28	0.45	0.27	0.59	0.40	1.12	0.37	1.06

[a] All values represent means of three replicated experiments
[b] TBA values expressed as mg malonaldehyde/kg meat
[c] Sensory scores: 0 = no WOF; 5 = intense WOF

Table 2. Mean TBA values and sensory scores for restructured beef steaks during frozen storage.[a,b]

Treatment	Month 0		Month 3		Month 6	
	TBA	Sensory	TBA	Sensory	TBA	Sensory
Salt	1.34	1.19	3.93	3.08	5.29	3.83
Salt/STPP	0.29	0.31	2.14	2.58	3.04	3.00
Salt/OR (0.05%)	0.76	1.06	2.52	2.06	3.22	2.92
Salt/OR (0.1%)	0.56	0.86	1.61	1.67	2.41	2.58
Salt/STPP/OR (0.05%)	0.27	0.47	1.36	1.17	2.37	2.86
Salt/STPP/OR (0.1%)	0.27	0.42	1.18	1.13	1.77	2.20
Salt/STPP/TBHQ	0.28	0.45	0.78	1.17	1.89	2.11

[a] All values represent means of three replicated experiments.
[b] Representatives steaks were thawed after 3 and 6 months at -20C, cooked, and analyzed for TBA value and sensory score.

Table 3. TBA values and sensory scores of chicken nuggets during refrigerated storage

Treatment[a]	Day 0		Day 2		Day 4		Day 6	
	TBA	Sensory	TBA	Sensory	TBA	Sensory	TBA	Sensory
Salt	1.67	1.71	3.29	2.92	4.36	3.53	5.13	3.77
Salt/STPP	0.64	0.93	1.26	2.00	2.36	2.37	2.65	2.31
Salt/OR (0.05%)	1.28	1.38	2.76	2.98	4.05	3.37	4.57	3.69
Salt/OR (0.1%)	0.94	1.50	2.15	2.43	3.19	3.65	3.75	3.93
Salt/STPP/OR (0.05%)	0.50	0.32	0.97	1.31	1.65	1.70	1.78	2.23
Salt/STPP/OR (0.1%)	0.46	0.63	0.75	1.36	1.20	1.80	1.47	2.06
Salt/STPP/TBHQ	0.38	0.30	0.47	1.08	0.62	1.27	0.59	1.73
Oil + OR[b] (0.025%)	0.58	0.93	1.11	1.54	1.66	1.97	2.43	2.37
Oil + OR (0.05%)	[b]0.64	0.73	1.40	2.00	2.13	2.17	2.56	2.60

[a] All values represent average of three replicated experiments
[b] Samples fried in oil containing OR contained salt and STPP.

Table 4. TBA values and sensory scores of chicken nuggets during frozen storage.

Treatment[a]	Month 0		Month 2		Month 4		Month 6	
	TBA	Sensory	TBA	Sensory	TBA	Sensory	TBA	Sensory
Salt	1.67	1.71	3.29	4.38	3.65	3.67	3.61	4.33
Salt/STPP	0.64	0.93	1.15	2.15	1.99	2.93	1.58	2.40
Salt/OR (0.05%)	1.28	1.38	2.73	3.82	3.24	4.00	3.57	4.17
Salt/OR (0.1%)	0.94	1.50	2.44	3.38	2.85	3.90	2.78	4.00
Salt/STPP/OR (0.05%)	0.50	0.32	0.98	1.82	1.35	2.03	1.35	2.40
Salt/STPP/OR (0.1%)	0.46	0.63	0.99	1.90	0.97	1.90	1.19	2.33
Salt/STPP/ TBHQ	0.38	0.30	0.52	1.35	0.48	1.37	0.54	1.57
Oil + OR[b] (0.025%)	0.58	0.93	1.27	2.03	1.51	2.87	1.59	2.77
Oil + OR (0.05%)	0.64	0.73	1.30	2.48	2.11	2.40	1.82	2.93

[a]All values represent means of three replicated experiments.
[b]Samples fried in oil containing OR contained salt and STPP.