THE EFFECT OF ANTIOXIDANTS ON THE STORAGE LIFE OF RESTRUCTURED PORK CHOPS

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SUMMARY

Restructured pork was manufactured using boneless, flaked shoulders with various adjuncts to determine their value for protecting appearance traits and taste attributes during frozen storage. The adjuncts involved in Study A were butylated hydroxyanisole (BHA), ascorbic acid (AA), and sodium tripolyphosphate (STP). Potassium chloride (KCl), STP and lecithin were evaluated in Study B. Quality attributes that were evaluated included cohesiveness, overall appearance, flavor, juiciness, texture and oxidative rancidity.

The use of BHA alone and in combination with STP and/or AA was effective in maintaining acceptable color and flavor and low oxidative rancidity (TBA values) for up to 60 days. Samples with STP and AA maintained acceptability of these traits for 30 days, although AA alone was less effective. The best results were obtained with BHA, AA and STP in the formulation. Objective and subjective measurements of color and other visual traits revealed that storage time affected these attributes more than the adjuncts; whereas, all treatments had a minimal effect on texture and juiciness. Increased frozen time and lecithin contributed to flavor degradation and increased TBA values. Further research is needed to determine the effect of lecithin on the oxidative rancidity of restructured muscle foods.

INTRODUCTION

The increased consumer demand for steaks and other portion control cuts in the United States has been responsible for increased production of restructured muscle foods. Restructuring of muscle foods is the binding together of boneless pieces, that may range in size from finely comminuted particles less than 3 millimeters (mm) in diameter through large chunks of intact muscles, into a desired shape, thickness and composition. The binding process is achieved by solubilizing the myofibrillar proteins. This process is accomplished by mixing and/or massaging and is known to be enhanced by the presence of NaCl and phosphates.

Reduction of muscle to various particle sizes increases the surface area which makes it easier to solubilize the proteins and provide the restructured product an acceptable texture. The larger surface area of comminuted muscle when exposed to air can enhance color degradation and oxidative rancidity after prolonged frozen storage of fresh or precooked meats. This deterioration process can result from the autooxidation of lipids and phospholipids found in muscle.

Sensory characteristics of restructured muscle foods are favorably and unfavorably affected by non-meat ingredients. Mandigo et al. (1982), and Marriott et al. (1983) have reported that sensory panelists prefer restructured products with NaCl because it increased flavor and juiciness. However, salt has detrimental effects on color and flavor stability (Huffman, et al. 1981b; Marriott et al. 1983). Schwartz and Mandigo (1976) found that STP in restructured formulations improved raw color and juiciness. Huffman et al. (1981a) reported that the combination of NaCl and STP improved the sensory properties of restructured products over STP or NaCl alone in all traits except juiciness and flavor. The use of other non-meat ingredients in restructured muscle foods has been studied less extensively.

Ockerman and Organisciak (1979) suggested that oxidation could be reduced by the addition of phosphates or antioxidants to restructured meats. An antioxidant appears to function by extension of the induction period of the oxidation process due to the absorption of the activity energy of peroxides (Anonymous, 1983). More than one mechanism may occur and the electron or hydrogen donation is the primary reaction with the secondary reaction being the formation of a loose complex between the antioxidant and the fat chain. Certain compounds such as lecithin, phosphates, citric acid and ascorbic acid react as synergists to enhance the effect of phenolic antioxidants. Synergists appear to chelate metals which normally accelerate oxidation, reduce the oxidized forms of the primary antioxidant to effectively renew the antioxidant's activities, or absorb the activation energy for fat oxidation to effectively break the chain reaction of fat oxidation.

Food processors should be more concerned with the stability of restructured muscle foods. Oxidation of lipids and meat pigments contribute to degradation of these products. Rancidity development has been a major factor involved in the discontinuation of the production of various restructured products. This problem has been tackled by the evaluation of antioxidants and other non-meat ingredients. Smith (1982) reported that restructured steaks with butylated hydroxyanisole (BHA) were superior in flavor. This researcher stated that incorporation of NaCl, STP and BHA was responsible for lower TBA values. Chastain et al. (1982) studied the effect of BHA, tertiary butylhydroquinone (TBHQ) and a combination of these two antioxidants in restructured beef/pork steaks and found that flavor and overall acceptability were significantly superior to the control samples. These workers concluded that the combination of BHA and TBHQ offered the best possibility for protection against oxidative changes of the fat and pigment.

The effect of the previously mentioned synergists in combination with a flavor enhancer, such as sodium chloride, on appearance and taste attributes has not been fully delineated. Therefore, our studies were designed to observe the effects of non-meat adjuncts on the stability of appearance and taste attributes of restructured pork chops.

MATERIALS AND METHODS

Study A

The shankless shoulders of U.S. 1 pork carcasses that weighed 105-125 kg were boned at 72 hours postmortem. The lean was frozen, tempered to -4°C and flaked through a Ross Unicom (prototype) flaker to create particles of ca 3mm in diameter. The fat trimmings were handled the same except that this material was ground through a 3.2mm plate. The lean and fat portions were mixed to create a product with 20% fat.

Treatment allocation involved (1) 0.75% NaCl (control); (2) 0.75% NaCl and 0.01% BHA; (3) 0.75% NaCl and 0.01% AA; (4) 0.75% NaCl, 0.01% BHA and 0.01% AA; (5) 0.75% NaCl and 0.125% STP; (6) 0.75% NaCl, 0.125% STP and 0.01% BHA; (7) 0.75% NaCl, 0.125% STP and 0.01% AA; (8) 0.75% NaCl, 0.125% STP, 0.01% BHA and 0.01% AA. These samples were blended for eight minutes, frozen, tempered at -4°C for 25 hr., converted into restructured chops formed by a Ross Superform 720 Press at ca 30 kg/cm^2 with a dwell time of two seconds, cut into 1 cm thick portions and

stored at -18°C until evaluation time. Packages of samples from each treatment were randomly selected at 0, 30, 60 and 90 days of storage for subsequent chemical analyses, subjective evaluations and physical measurements.

Composite samples for each treatment were analyzed in triplicate to determine fat, salt and TBA values (Malonaldehyde content) at 0, 30, 60 and 90 days. These samples were cooked for 4 minutes in an electric frying pan, set at 176.7°C, by turning at one minute intervals to give an internal temperature of 70°C. The cooked samples were then subjectively evaluated by a sensory panel.

Subjective evaluations of sensory attributes and visual criteria for each treatment were conducted by five panel members at 0, 30, 60 and 90 days. Panelists performed blind multiple comparison evaluations as described in Kramer and Twigg (1970). The ratings and descriptions of sensory attributes were: flavor (5=very desirable; 1=undesirable) and juiciness (5=very juicy; 1=very dry). A frozen sample from each treatment was evaluated for visual cohesiveness (5=cohesive texture; 1=loose, coarse texture), color (5=pink red; 1=overall dark brown), and overall appearance (5=highly acceptable; 1=unacceptable).

Analysis of variance was performed (SAS, 1979) to determine significant differences between treatments. Where differences ($P<0.05$) were found, mean separation was conducted (Duncan, 1955).

Study B

Pork samples were obtained as Described for Study A. The comminuted material was blended for 3 minutes in a ribbon-paddle mixer with 1.0% NaCl and 0.,25 STP (S samples), 0.5% NaCl, 0.5% KCl and 0.25% STP (SK samples); 1.0% NaCl, 0.25% STP, and 0.125% lecithin (SL samples) or 0.5% NaCl, 0.5% KCl, 0.25% STP and 0.125% lecithin (SKL samples).

The blended samples were stuffed into 11 cm diameter casings and subsequently frozen and stored at -18°C for 24 hours. The frozen product was then tempered and pressed into the shape of boneless pork chops as described for Study A. Packaging and storage conditions were the same as for Study A. Evlauations of all four treatments were conducted at 5, 15, and 56 days.

Frozen samples from all treatments were subjectively rated for color, overall appearance, tenderness, texture, and flavor by a six-member panel. Rating scales were: an 8 point scale for color, overall appearance, texture, juiciness and flavor (8=very desirable; 1=very undesirable). Samples from all treatments were objectively evaluated for color by use of the Hunter Color Difference Meter. Oxidative rancidity was measured by the TBA Test (Tarladgis et al., 1960). Total sample size was: 4 formulations x 3 evaluation periods x 6 replications per treatment = 72. Statistical analyses were by the same procedures as for Study A.

RESULTS AND DISCUSSION

Study A

The use of STP and NaCl provided no protection, since the TBA values were the same or higher ($P<0.05$) when compared to samples containing only NaCl (control). This agrees with Schwartz and Mandigo (1976) and Smith (1982) who reported that STP does not decrease TBA values in raw meat. STP did interact with BHA and AA singly to protect against oxidation of fat during storage. Generally, samples containing BHA had lower ($P<0.05$) TBA values than samples without BHA. Ascorbic acid lowered ($P<0.05$) TBA values for up to 30 days, after which there was no difference ($P>0.05$).

The interaction of STP with antioxidants and antioxidants with each other lowered ($P<0.05$) TBA values. The addition of BHA and STP to restructured pork was responsible for lower TBA values for up to 30 days when compared to those with BHA alone, STP alone and those not containing STP, or BHA. After 30 days, BHA and STP increased TBA values of the samples compared to those with BHA alone. Although BHA alone provided better protection after 60 days, the BHA and STP combination provided protection against oxidation as indicated by the lower ($P<0.05$) TBA values when compared to samples with STP alone, the control and those without BHA after 90 days of frozen storage.

The combination of STP and AA gave lower TBA values initially and after 30 days of frozen storage. After 30 days, AA was no longer beneficial in controlling oxidative rancidity. The combination of AA and BHA gave lower ($P<0.05$) TBA values when compared to samples with AA alone or those without AA or BHA.

Antioxidants had no consistent effect ($P>0.05$) on texture and juiciness at any time period. Texture and juiciness of all samples did not change ($P>0.05$) over time and were in the acceptable range. Samples containing antioxidants were rated higher ($P<0.05$) for juiciness than those with NaCl only or NaCl and STP. There was no effect ($P>0.05$) on juiciness due to the presence of STP in treatments 5, 6, 7 and 8 vs 1, 2, 3 and 4. This observation disagrees with Schwartz and Mandigo (1976) and Keeton (1983) who found that STP increased juiciness scores of flaked products, but agrees with Huffman et al. (1981b). At 0 days, the flavor for all of the samples were rated above the acceptable (3.0) range (Table 1). Thus, the addition of antioxidants had no detrimental effect on initial flavor. All treatments maintained acceptable flavor for 30 days. Then, the flavor of samples containing AA only decreased ($P<0.05$) after 60 days of storage. The flavor scores of all samples except those containing AA only; STP and AA; STP and BHA; and STP, BHA, and AA were lower ($P<0.05$) at 90 days than at 0 days of frozen storage. The flavor of samples containing STP, BHA, and AA (Treatment 8) did not change ($P>0.05$) during frozen storage. Samples with BHA rated higher ($P<0.05$) in flavor at 30 and 60 days. After 90 days, the AA samples received higher ($P<0.05$) flavor scores than Treatments 1, 2 and 5.

Cohesion and fat dispersion were not affected ($P>0.05$) by storage time. All samples were rated moderately cohesive. Samples containing NaCl only, STP only, and STP and BHA differed ($P<0.05$) in cohesiveness from the other treatments but were still acceptable. These scores indicate that there were no detrimental effects on flaked and formed pork products by the addition of antioxidants.

The data for color and appearance changed ($P<0.05$) over storage time. Color for all samples except those containing only AA were in the acceptable range at 0 days of storage. The reduced color for samples containing AA at 0 days may be due to the ability of AA to function as a pro-oxidant. After 30 days of frozen storage, the color ratings for all samples decreased ($P<0.05$) except for those containing only AA. Samples containing BHA; STP and BHA; STP and AA; and STP, BHA and AA had higher ($P<0.05$) color scores than the control or other treatments at 30 days. After 30 days of storage, only samples containing STP and BHA and STP, BHA and AA maintained a moderately acceptable color. These two treatments had higher ($P<0.05$) color scores than NaCl alone at these storage times. The use of STP with BHA and STP with BHA and

TABLE 1

Effect of antioxidants on flavor [1,2]

Treatment	Days of frozen storage			
	0	30	60	90
I. NaCl	3.4^{ab}_{w}	3.4^{bc}_{w}	3.2^{cd}_{wx}	2.9^{c}_{x}
II. NaCl, BHA	3.8^{a}_{w}	3.6^{ab}_{wx}	3.3^{bc}_{x}	2.8^{c}_{y}
III. NaCl, AA	3.6^{ab}_{w}	3.4^{b}_{w}	2.8^{d}_{x}	3.2^{abc}_{wx}
IV. NaCl, BHA+AA	3.6^{ab}_{w}	3.7^{ab}_{w}	3.4^{abc}_{wx}	3.1^{abc}_{x}
V. NaCl, STP	3.6^{ab}_{w}	3.4^{b}_{wx}	3.2^{cd}_{x}	3.0^{abc}_{x}
VI. NaCl, STP, BHA	3.4^{b}_{xy}	3.8^{a}_{w}	3.5^{abc}_{wx}	3.0^{bc}_{y}
VII. NaCl, STP, AA	3.4^{ab}_{x}	3.9^{a}_{w}	3.7^{a}_{wx}	3.4^{ab}_{x}
VIII. NaCl, STP, BHA+AA	3.8^{ab}_{w}	3.9^{a}_{w}	3.8^{a}_{w}	3.5^{a}_{w}

[1]Each value is an average of 20 observations/treatment at each storage time.

[2]Scale 1-5 (1=undesirable, 3=acceptable and 5=very desirable).

[abcd]Means in the same column with identical superscripts are not different (P>0.05).

[wxy]Means in the same row with identical subscripts are not different (P>0.05).

AA was more effective in protecting the color for all storage times than BHA alone.

Appearance of the samples followed a trend similar to color, since this variable is an important factor in determining general appearance. The exceptions to this observation were treatments 4, 6 and 7 which were rated moderately acceptable at 60 days. Furthermore, these treatments were superior (P<0.05) to the control. The higher ratings at 60 days may be due to better cohesion in the 60 day samples since both cohesion and fat dispersion are considered in general appearance evaluation.

Study B

Color Scores did not differ (P>0.05) among any of the formulations that were held for the same amount of time, except the SL samples that were stored for 56 days. These chops received lower (P<0.05) scores than the SK samples evaluated at the same time. Although this difference was significant (P<0.05), it is not practical since the variation was only 0.6 on the rating scale and both samples were rated between 4 and 5. Color ratings were affected more by storage time than by adjuncts incorporated in the four formulations. All S, SL and SKL samples received higher (P<0.05) color scores at 5 days than at 14 and 56 days. None of the treatments that were stored for 56 days received lower (P<0.05) scores than those evaluated at 14 days. Lecithin was ineffective as a synergist since it did not positively influence color scores at any storage time. Although the maximum variation in color scores was only 1.5 on the rating scale, scores at 5 days were low enough to suggest color degradation from the NaCl. Schwartz and Mandigo (1976), and Marriott et al. (1983) have previously reported that NaCl contributes to color degradation of restructured meats during storage.

None of the Hunter 'a' values (redness) of the samples for 5 days were different (P>0.05). After 14 days of storage, the 'a' values of the SK, SL and SKL samples were not different (P>0.05) from each other, but all were lower (P<0.05) than the S chops. Following 56 days of storage, the 'a' values of the S chops were higher (P<0.05) than the SL and SKL samples and the SL chops had lower 'a' values than the SK samples. Again, no positive effect of lecithin was found.

These data illustrated that the 'a' values of all treatments after 56 days of storage were lower (P<0.05) than for the same formulations stored for 5 or 14 days. The 'a' values of the S chops evaluated at 5 days were not different (P>0.05) from those stored for 14 days, but the Hunter color values for the other formulations were lower (P<0.05) after 14 days storage than when evaluated at 5 days.

A correlation of 0.78 between color scores and overall appearance data suggested a definite relationship (P<0.001) between these two measurements. Restructured chops from all formulations received higher (P<0.05) overall appearance scores after 5 days storage than when evaluated at 14 or 56 days. None of the samples stored for 14 and 56 days differed (P>0.05) from each other, except that scores of the SK chops evaluated at 14 days were higher (P<0.05) than the SL samples stored for 56 days. No differences (P>0.05) in overall appearance values were found among the different formulations that were stored for the same number of days. Overall appearance was affected more by storage time than by adjuncts.

This research revealed that a 50% replacement of NaCl with KCl will not affect texture. Juiciness was not affected by those adjuncts that were incorporated or by frozen storage times that were selected. Flavor scores of S and SK chops did not differ (P>0.05)

among the storage periods. Also, flavor scores did not differ ($P>0.05$) among the formulations that were evaluated at 5 and 14 days. The SL chops evaluated at 56 days sustained more ($P<0.05$) flavor degradation than at 5 days. At 56 days, the SKL chops received lower ($P<0.05$) flavor scores than all samples, at all storage times. These data suggest that lecithin and KCl were not flavor protectors during a prolonged storage time.

The TBA values further suggest that lecithin did not function as an antioxidant. Those restructured chops that contained lecithin (SL and SKL samples) and were stored for 14 or 56 days had higher ($P<0.05$) TBA values than all other treatments except the S chops that were evaluated after 56 days of frozen storage. The TBA values compared favorably with the flavor scores since no differences in TBA values occurred among the formulations evaluated after 5 days of frozen storage. Further agreement is evidenced by the higher ($P<0.05$) TBA values of the SL and SKL samples after prolonged storage. This observation is further supported through the trend toward higher ($P<0.05$) TBA values with increased storage time as evidenced by higher ($P<0.05$) values from 14 to 56 days for the S and SK samples and from 5 to 14 days among the SL and SKL chops.

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