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Effects of Salt and Some Antioxidants Upon the TBA Numbers of Meat*

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ABSTRACT

The effects of salt alone (2%) or coated with α-tocopherol or with Tenox 4 (BHA–citric acid–propylene glycol) or in a mixture containing BHA and BHT with salt on the TBA numbers of raw and cooked beef were determined after holding for 0 or 2 days at 4°C. Salt accelerated lipid oxidation both during cooking and subsequent storage. The α-tocopherol-coated salt also increased lipid oxidation, but only during storage after cooking. Both Tenox 4-coated salt and the mixture of BHA and BHT with salt completely inhibited lipid oxidation in cooked meat, both during cooking and upon subsequent storage. Results suggest that selected antioxidants can be used to inhibit the development of warmed-over flavor (WOF) in cooked meats.

INTRODUCTION

Several research reports (Chang & Watts, 1950; Zipser *et al.*, 1964; Ellis *et al.*, 1968; Olson & Rust, 1973) have shown that salt accelerates lipid oxidation in meat. A number of antioxidants, including butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), citric acid and propylene glycol, have been reported to be effective antioxidants in meat

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products (Kraybill *et al.*, 1949; Bentz *et al.*, 1952; Hanely *et al.*, 1953; Lew & Tappel, 1956; Tollenaar & Vos, 1958). More recently, mixing or coating of the antioxidants onto a salt carrier has been suggested as serving to solubilize and improve the uptake of antioxidants by the tissue lipids (Reddy *et al.*, 1982), with application of α-tocopherol-coated salt effectively inhibiting the formation of *N*-nitrosopyrrolidine during the cooking of cured bacon (Gray *et al.*, 1982).

The present study was designed to test the effects of salt alone, and in combination with antioxidants, upon the development of rancidity under conditions that normally produce warmed-over flavour (WOF) in cooked meats (Igene & Pearson, 1979).

METHODS AND MATERIALS

Samples of lean meat (Chen *et al.*, 1984) weighing 1300 g were thawed and ground through a plate containing 1·59 cm holes and then through a second plate with 0·95 cm holes. Each ground meat sample was divided into five equally sized portions and Alberger Fine Flake Salt (Diamond Crystal Salt Co., St. Clair, MI, USA) was added to all samples, except for the unsalted controls, according to the treatment schedule shown in Table 1.

Treatment No. 1 included the control samples and did not contain any added salt or antioxidants. In treatment No. 2, NaCl was added at the 2% level but did not contain any antioxidants. Treatment 3 also had 2% added NaCl, which was coated with 3·75% of α-tocopherol to give a final concentration of 0·02% α-tocopherol in the fat (2·2%) of the meat samples. Treatment No. 4 was compounded to contain 2% NaCl coated with Tenox 4 to give final concentrations of 0·01% BHA, 0·007% citric acid and 0·005% propylene glycol in the fat of the samples. Treatment 5 contained 2% NaCl mixed to give 0·01% BHA and 0·01% BHT in the fat of the meat. It was necessary to adjust the antioxidant contents to the specified levels in the fat by adding additional NaCl without any antioxidants since the level of combined antioxidants is limited to 0·025%, and that of any single antioxidant to 0·01%, of the fat content of the samples. The salt and antioxidants were added to the meat during grinding to ensure a uniform mixture.

One-third of the meat in each treatment was used as raw samples while the remaining meat was cooked. After cooking, half the samples were

TABLE 1
TBA Numbers of Raw Meat and Heated Meat with and without Antioxidants and Salt*†

Treatment group		*Raw meat*	*Cooked meat***‡*	
			0 days	*2 days*
1	Control without salt	$0{\cdot}53^{f}$	$1{\cdot}54^{g}$	$4{\cdot}43^{i}$
2	2% NaCl without antioxidants	$0{\cdot}54^{f}$	$2{\cdot}25^{h}$	$8{\cdot}25^{k}$
3	2% NaCl with α-tocopherol coated on the salt	$0{\cdot}54^{f}$	$1{\cdot}40^{g}$	$6{\cdot}23^{j}$
4	2% NaCl with Tenox 4# coated on the salt	$0{\cdot}56^{f}$	$0{\cdot}52^{f}$	$0{\cdot}42^{f}$
5	2% NaCl plus 0·01% BHA and 0·01% BHT mixed with salt	$0{\cdot}56^{f}$	$0{\cdot}52^{f}$	$0{\cdot}41^{f}$

* Each value represents five replicate samples. Raw meat was tested immediately after the addition of additives.

† TBA values with different superscripts were significantly different from each other at $P < 0{\cdot}05$.

** The cooked meat was stored at 4 °C for 48 h.

‡ The fat content of the meat samples was 2·26%.

Tenox 4 was coated on the salt to give a final concentration of 0·01% BHA, 0·007% citric acid and 0·005% propylene glycol in the meat when salt was added at the 2% level.

immediately analyzed by the TBA test (Tarladgis *et al.*, 1960), whereas the remaining cooked samples were held for 2 days at 4 °C before being analyzed for TBA numbers. The TBA test was also carried out on the raw meat immediately after the addition of antioxidants.

Cooking of the samples was carried out in retortable plastic pouches left open at one end and heated in boiling water until the internal temperature reached 70 °C. They were then cooled in cold running tap water. Drippings were mixed with the meat before TBA analysis, which was carried out at once.

Mean values were subjected to analysis of variance as described by Gill (1978). Statistical significance is reported at the 5% level ($P < 0{\cdot}05$).

RESULTS AND DISCUSSION

The results of adding salt and antioxidants are summarized in Table 1. TBA numbers for all raw samples, which were measured immediately

after adding the salt treatments to the samples, were all relatively low and not significantly different ($P < 0{\cdot}05$) from each other. Thus, there was little or no oxidation immediately after treatment. The TBA values were comparable with other literature values (Wilson *et al.*, 1976; Igene & Pearson, 1979) and are considerably lower than the value of 1–2 reported by Watts (1962) as the threshold for sensory detection of rancidity.

After heating (0-day), the TBA values for the samples treated with α-tocopherol-coated salt were not different from the unsalted controls, but were significantly lower ($P < 0{\cdot}05$) than that of the samples containing only salt (Table 1). After 2 days' storage at 4°C, however, the TBA numbers of the meat containing α-tocopherol-coated salt were significantly higher ($P < 0{\cdot}05$) than those of the unsalted control, but were significantly lower than those containing only salt. Although the α-tocopherol-treated salt had an antioxidative effect, the values were all well above the threshold level (Watts, 1962) and are of doubtful significance. The ineffectiveness of the α-tocopherol-coated salt in preventing oxidation may be related to previous reports by Chippault (1961) and Labuza (1971) which suggest that α-tocopherol is sometimes an antioxidant and, under other conditions, acts as a pro-oxidant.

Both Tenox 4-coated salt and the mixture of BHA and BHT added to the salt were effective antioxidants on cooked refrigerated meat during storage at 4°C for 2 days. Both treatments were equally effective for inhibiting oxidation, as can be seen from the data in Table 1.

The results of this study indicate that Tenox 4-coated salt and a combination of BHA and BHT with salt were very effective antioxidants. Since these two salt antioxidant treatments prevented the development of rancidity in precooked meats, the results suggest they may be useful for inhibiting the development of WOF in cooked meat products.

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