4 - 32 ANTIOXIDATIVE PROPERTIES OF ALPHA-TOCOPHEROL IN COOKED PORK

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The effect of α-tocopherol (0, 100 or 200 ppm) on lipid oxidation either in cooked or uncooked ground pork was studied during aerobic storage at 4 C and -20 C. Lipid oxidation was measured with the 2-thiobarbituric acid (TBA) method and oxidized flavor development was evaluated by a trained sensory panel. Uncooked pork was much less susceptible to oxidation than was cooked pork and had less oxidized flavor after storage at either 4 or -20 C. Tocopherol reduced the rate of oxidation in cooked product stored at 4 or -20 C as measured with TBA number. But significant oxidation still occurred at 4 C, even in the presence of added tocopherol and the sensory panel detected high levels of oxidized flavor in all tocopherol treatments. Tocopherol was effective in maintaining low TBA numbers and low oxidized flavor in cooked pork stored at -20 C. Prerigor grinding did not effectively inhibit oxidation in cooked products stored at 4 C, but sensory scores suggested inhibition when storage was at -20 C. TBA numbers increased during storage of cooked product at 4 C with an increase in internal cooking temperature between 50 and 80 C.

INTRODUCTION

Pork oxidizes rapidly because of its relatively high content of unsaturated fatty acids. Cooked pork is more easily oxidized than uncooked pork and develops warmed-over flavor in a few hours when stored at 4 C. Chemical substances such as propyl gallate, BHA, citric acid, polyphosphates and sodium ascorbate are effective antioxidants in uncooked meat but their effectiveness in cooked meat is limited. Alpha-tocopherol, a naturally occurring antioxidant, retards oxidation in uncooked meat and one researcher (Yamauchi et al., 1977) reports effectiveness in cooked meat during short storage periods. Prerigor grinding also retards oxidation in fresh pork (Judge and Aberle, 1980).

This study was conducted to determine the effects of α-tocopherol as an antioxidant in either cooked or uncooked fresh ground pork and to determine the combined effect of prerigor processing and α-tocopherol on lipid oxidation in cooked pork.

EXPERIMENTAL

Shoulder muscles from 100-kg pigs were used for these studies. Muscle was ground, the last grinding through a plate with 4.8 mm holes, and then assigned to experimental treatments.

EXPERIMENT 1, effect of tocopherol on lipid oxidation in postrigor ground pork, consisted of four complete replicates. Ground pork was prepared from chilled carcasses at 24 h postmortem. Either 0, 100 or 200 ppm dl-α-tocopherol dissolved in partially hydrogenated soybean oil was added; the amount of soybean oil used was 1% (w/w) for all treatments. After tocopherol addition, the ground pork was formed into patties weighing approximately 100 g. Half of the patties were cooked to an internal temperature of 70 C. Within each tocopherol treatment, the cooked and uncooked patties were allotted to storage at 4 C or -20 C. The refrigerated patties were wrapped in oxygen permeable, moisture impermeable polyvinyl chloride (PVC) film and frozen patties were wrapped in PVC film and overwrapped with freezer paper. Lipid oxidation was measured using the 2-thiobarbituric acid (TBA) method and warmed-over or oxidized flavor was evaluated by a trained taste panel after various storage times.

EXPERIMENT 2, effect of prerigor versus postrigor grinding on lipid oxidation of cooked pork in the presence of tocopherol, consisted of two complete replicates. Prerigor samples were prepared from muscles removed from one side of the carcass within 45 min postmortem and ground within 90 min postmortem. Postrigor samples were from the opposite carcass sides at 24 h postmortem. Preparation of samples, addition of tocopherol, patty making and packaging were accomplished as described for Experiment 1. All patties were cooked after 24 h postmortem and stored at either 4 or -20 C. TBA measurements and sensory evaluations were performed after various storage times.

EXPERIMENT 3, effect of endpoint cooking temperature upon lipid oxidation, consisted of three complete replicates. Tocopherol was added to postrigor ground pork, patties were prepared and cooked to internal temperatures of 50, 60, 70 or 80 C. Temperature was monitored with copper-constantin thermocouples. After cooking, cooking losses were measured and the patties were refrigerated at 4 C. TBA numbers were measured at various times of storage and expressed on the basis of the original uncooked meat weight.

RESULTS AND DISCUSSION

EXPERIMENT 1. TBA numbers increased during storage of both control and tocopherol-treated cooked pork stored at 4 C (Figure 1). Tocopherol-treated patties had lower ($P<.05$) TBA numbers than those without tocopherol. But the sensory panel did not detect flavor differences among control and tocopherol-treated cooked samples stored at 4 C (Table 1) because all treatments had noticeable off-flavor after 3 d of refrigeration and panelists had difficulty in discriminating flavor differences.

Alpha-tocopherol also inhibited oxidation in cooked patties stored at -20 C in that treated patties had lower ($P<.05$) TBA numbers than control patties. TBA numbers remained below 2.1 during 21 d of storage and did not increase markedly during storage. The sensory panel detected more ($P<.05$) warmed-over flavor in control than 200 ppm-tocopherol-treated patties (Table 1).

Through 7 d of storage at 4 C, tocopherol addition did not affect either TBA numbers (Figure 2) or sensory panel scores (Table 1) of uncooked pork. But at 12 d, pork without added tocopherol had higher ($P<.05$) TBA numbers than tocopherol-treated product (Figure 2). Product stored 12 d at 4 C had significant microbial spoilage which made it unacceptable, even though tocopherol had an anti-oxidative effect at this time. TBA numbers were consistently low in all treatment combinations of uncooked pork stored at -20 C for 90 d and the sensory panel did not detect flavor differences after 60 d of storage.

EXPERIMENT 2. Prerigor grinding did not inhibit lipid oxidation as indicated by TBA analysis and sensory panel evaluation when pork muscle was cooked before storage and samples were stored at 4 C (Table 2). Several research groups have shown lower rates of oxidation in prerigor pork stored uncooked (Davidson et al., 1968; Judge and Aberle, 1980). Cooking increases susceptibility to oxidation to an extent to nullify most benefit of prerigor grinding. However, prerigor ground, cooked samples stored at -20 C tended to have less warmed-over flavor than postrigor ground samples stored similarly (Table 2). Effects of α-tocopherol on TBA values were similar to that observed in Experiment 1 and did not differ between prerigor and postrigor ground muscle. Taste panelists found less ($P<.05$) warmed-over flavor in postrigor ground pork with 200 ppm tocopherol than in the control when product was stored frozen (Table 2).

EXPERIMENT 3. Muscle samples cooked to higher internal temperatures were more susceptible to oxidation. TBA numbers obtained immediately after cooking reflect more oxidation ($P<.05$) at higher cooking temperature even though the time elapsed between completion of cooking and distillation for TBA analysis was 30 min (Figure 3). Samples cooked to higher temperatures had more rapid increases in TBA value during storage than those cooked to lower temperatures. These results may be explained by the fact that denaturation of lipoproteins in muscle cell membranes increases progressively with greater cooking temperature leaving the phospholipids more exposed to catalysts of oxidation (Sato and Hegarty, 1971). Further, greater amounts of ferric iron (Younathan and Watts, 1959), more free iron (Igene et al., 1979) and higher nonenzymatic oxidative activity of hemoprotein (Erikkson et al., 1971) occur as a result of higher cooking temperature.

SUMMARY AND CONCLUSIONS

Alpha-tocopherol slowed the rate of oxidation in cooked postrigor ground pork stored at either 4 or -20 C and in uncooked samples stored at 4 C for extended periods of time (12 d). But in cooked product stored at 4 C, oxidation progressed to an extent, even in the presence of α-tocopherol, that strong warmed-over flavor was present. In cooked pork stored at -20 C, sensory analysis and TBA numbers indicated benefits of α-tocopherol addition.

Prerigor grinding, known to induce high ultimate pH and inhibit lipid oxidation in uncooked pork, had no protective effect on oxidation as measured with TBA numbers in cooked ground pork regardless of storage conditions. However, sensory scores tended to indicate less warmed-over flavor in prerigor ground than postrigor ground samples stored at -20 C.

Alpha-tocopherol treatment of ground pork stored frozen in the precooked state can reduce its susceptibility to lipid oxidation and produce an acceptable product. Internal cooking temperatures of 70 C or greater should be avoided because the rate of lipid oxidation after cooking to high temperatures is very rapid.

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Table 1. Mean taste panel scores[a] of cooked and uncooked postrigor ground pork containing α-tocopherol (Experiment 1).

Treatment	Storage	Tocopherol concentration, ppm 0	100	200	SE[b]
Cooked	4C, 3d	2.44	2.68	2.46	.22
Cooked	-20C,14d	1.27[c]	.94[cd]	.67[d]	.13
Uncooked	4C, 7d	1.22	1.03	.78	.15
Uncooked	-20C,60d	.44	.45	.57	.07

[a] 0 = no warmed-over flavor, 5 = very strong warmed-over flavor.

[b] Standard error of least-squares mean.

[c,d] Means on the same line with different superscripts differ (P<.05).

Table 2. Mean taste panel scores[a] of cooked pork containing α-tocopherol and prepared by prerigor or postrigor grinding (Experiment 2).

Treatment: Grinding	Storage	Tocopherol concentration, ppm 0	100	200	SE[b]
Prerigor	4C, 4d	2.32[d]	3.17[c]	3.65[c]	.20
Prerigor	-20C,12d	.91	.92	.91	.12
Postrigor	4C, 4d	3.33[c]	2.99[cd]	2.71[d]	.18
Postrigor	-20C,12d	1.46[c]	1.16[cd]	.95[d]	.12

[a] 0 = no warmed-over flavor, 5 = very strong warmed-over flavor.

[b] Standard error of least-squares mean.

[c,d] Means on the same line with different superscripts differ (P<.05).

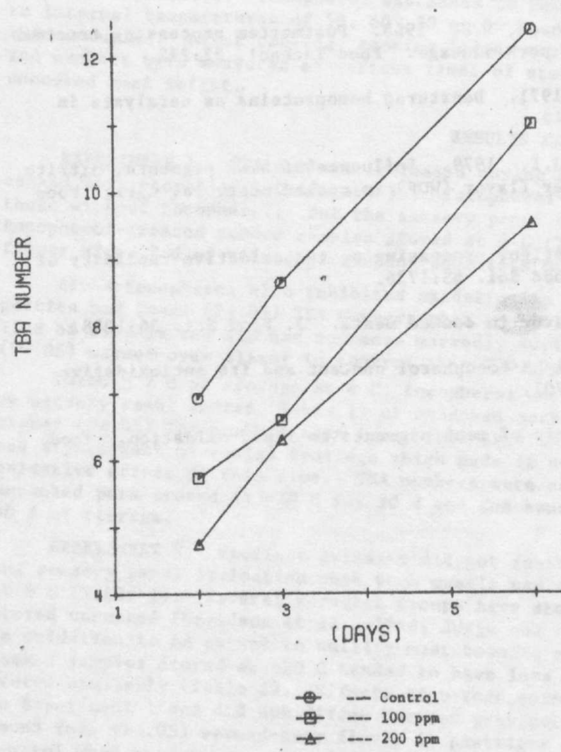

Figure 1. TBA numbers of cooked control and tocopherol-treated pork ground postrigor and stored at 4 C.

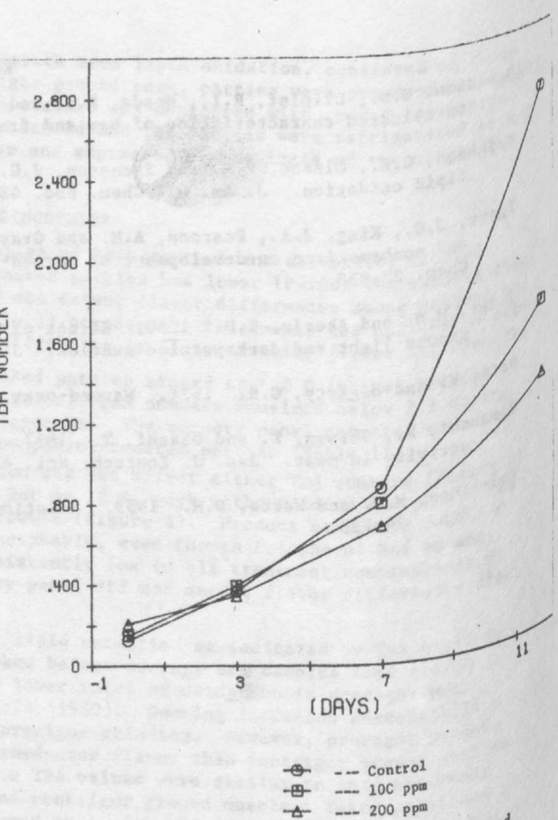

Figure 2. TBA numbers of uncooked control and tocopherol-treated pork ground postrigor and stored at 4 C.

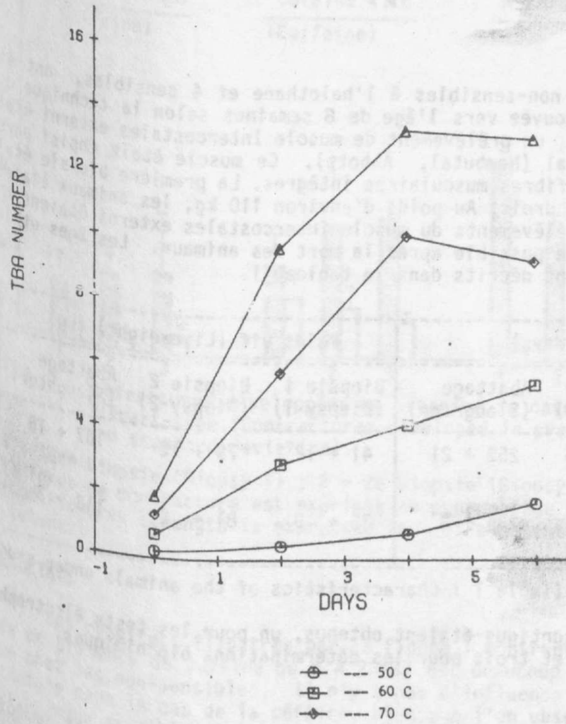

Figure 3. Effect of end point cooking temperature on TBA numbers of pork stored at 4 C.