EFFECT OF ASCORBIC ACID WITH TUMBLING ON LIPID OXIDATION OF PRECOOKED ROAST BEEF

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Background

Lipid oxidation in most cases deteriorates the quality of meat and causes unacceptable flavor for consumers. Buckley *et al.* (1989) reported that an increase of lipid oxidation would cause a decrease of flavor, color, texture, nutritional value and acceptability in meat. There are also some other detrimental effects regarding lipid oxidation, including decrease of shelf life, increase of off-flavor, change of the functional and sensory characteristics, and sometimes formation of carcinogenic substances (Ahn et al., 1992; Shahidi, 1994). Phospholipids, which are located in the cell membranes, are sensitive to oxidation in meat due to their more unsaturated fatty acids compared to other lipids. Lean meat contains a high percentage of phospholipids that makes it sensitive to oxidation (Igene et al, 1980). Therefore, phospholipids act as the major contributors to oxidative rancidity in meat.

The functions of ascorbic acid include stabilization of cured color and preservation of off flavor in meat (Bauernfeind, 1985). The ability of ascorbic acid, erythorbic acid, sodium ascorbate, and ascorbyl palmitate to stabilize lipid oxidation is due to their functions as oxygen scavengers (Jadhav et al., 1996), and it is used to regenerate the activity of primary antioxidants and to inactivate prooxidants (Bauernfient and Pinkert, 1970).

Tumbling has been reported to increase the distribution of food additives (Ockerman and Dowiercial, 1980) and this process should increase the distribution of ascorbic acid in the muscle tissue.

Objectives

The objective of this study was to investigate the combination of ascorbic acid with tumbling for retarding lipid oxidation in precooked roast beef.

Methods

All beef bottom round were cut into uniform roasts (8 x 8 x 8 cm dimensions). The ascorbic acid solution was needle injected with a hand medical hypodermic syringe at eight locations for each roast to 5% of green weight. For A1, A2, A3, A4 treatments, roast beef were injected with 0, 550, 1000 and 5000 ppm ascorbic acid, respectively. A1, A2, A3, A4 were not tumbled. Treatments A5, A6, A7 and A8 were intermittent non-vacuum tumbled for 18 hours (10min/hr), and they also were individually injected with 0, 550, 1000 and 5000 ppm ascorbic acid, respectively. Then, roasts were cooked with a hot-air convection oven until the internal temperature reached 71°C. A modified extraction of the TBARS method was analyzed for lipid oxidation (Pensel, 1990). The results of samples were evaluated for yield, pH, moisture, and Warner-Bratzler shear value (Ockerman, 1985). Modified ferrozine assay for total iron was from Stookey (1970) and Clark et al. (1997). Total pigment test followed the modified method from Ockerman (1985). Heme iron was calculated by the modified technique of Clark et al. (1997); the iron content is calculated with the factor of 0.0882 μg/μg hematin (Merck, 1989). (Nonheme iron of sample = Total iron content – Heme iron content). Total aerobic, psychrophilic, and thermophilic bacteria tests were utilized to detect contamination of various bacteria in precooked roast beef (Speck, 1984).

This study was a 4x2x4 factorial experiment, 4 levels of sodium tripolyphosphate (0, 0.25, 0.4 and 0.5%), tumbling (nontumbled or tumbled), and 4 days of storage (day 0, 2, 4 and 7). However, cooking yield was measured at day 0 and total plate counts were determined at day 7.

Results and discussions

There was no significant two-way (concentration x tumbling) for yield. The addition of different levels of ascorbic acid did not affect yield (Table 1). Also, all samples had the same cooking yield when tumbled and non-tumbled samples were compared.

For pH, the significant two-way interaction occurred between ascorbic acid level and storage time (Table 2). The sample without ascorbic acid had a significantly higher pH value compared to different ascorbic acid levels up to day 7. In general, the 1000ppm and 5000ppm maintained significantly lower pH values during 7-days of refrigerated storage. The pH of roast beef was primarily dependent on the levels of ascorbic acid added.

For TBARS values, only ascorbic acid level and storage time had significant two-way interaction; therefore, main effect is discussed for tumbling. Nontumbled roast beef had the same TBARS value as tumbled roast beef (Table 3). That is, tumbling did not influence lipid oxidation.

Table 4 shows the interaction between ascorbic acid level and storage time for TBARS value. The interaction of ascorbic acid level and storage time shows that samples with 0 ppm of ascorbic acid had a significantly higher TBARS value at day 2 compared to other levels of ascorbic acid. From day 0 to day 4, samples with added ascorbic acid had the same TBARS values; however, roast beef with 5000ppm was significantly lower TBARS values than those of 550 and 1000ppm of ascorbic acid at day 7. The treatment with 0 ppm of ascorbic acid at day 7 had a significantly higher TBARS value than those with all ascorbic acid levels as would be expected.

Table 1 Effect of ascorbic acid and tumbling on yield, psychrotrophile, mesophile, and thermophile of roast beef

Main effect Concentration of ascorbic acid	Yield	Psychrophilic $\log_{10}$CFU/g	Mesophile $\log_{10}$CFU/g	Thermophile $\log_{10}$CFU/g
0	54.71	1.87^{A}	2.38	2.35
550ppm	54.01	1.65^{A}	2.26	2.12
1000ppm	54.24	1.51^{AB}	2.18	2.11
5000ppm	54.71	1.10^{B}	2.17	1.97
Tumbling				
NonTumbled	53.76	1.55	2.26	2.04
Tumbled	54.22	1.52	2.24	2.23

^{AB}Means with different uppercase superscripts within a column, within main effect of concentration of ascorbic acid are significantly different ($p<0.05$)

Table 2 The pH values of precooked roast beef during refrigerated storage due to ascorbic acid level and storage time

Concentration of ascorbic acid	Storage		Time, days	
	0	2	4	7
0	5.76^{B}	5.76^{B}	5.76^{B}	5.82^{A}
550ppm	5.73^{BC}	5.76^{B}	5.75^{B}	5.74^{B}
1000ppm	5.67^{CD}	5.71^{BC}	5.67^{CD}	5.61^{DE}
5000ppm	5.58^{EF}	5.54^{F}	5.57^{EF}	5.55^{EF}

^{ABCDEF} All means with different uppercase superscripts are significantly different ($p<0.05$)

It seems that there was a decrease of lipid oxidation with increased concentrations of ascorbic acid. The results confirmed Wang et al.(1995) who reported that ascorbic acid is an effective antioxidant in cooked injected eye of round beef. Decker and Xu (1998) reported that

200-300 mg of ascorbic acid /kg of meat acted as a prooxidant, but ascorbic acid is an antioxidant at higher concentrations.

There was no significant three-way (concentration x tumbling x storage time) or two-way (concentration x tumbling, tumbling x storage time, concentration x storage time) interaction for moisture, shear values, total iron, heme iron and nonheme iron contents of precooked roast beef; therefore, main effects (concentration, tumbling and storage time) are discussed for these measurements as follows.

Ascorbic acid level and the tumbling process did not influence the moisture level of roast beef. However, the significantly lowest moisture content of roast beef was obtained at day 4 and 7 (Table 3). Due to unsealed packaging, the release of moisture increased over storage time.

For shear values, tumbled precooked roast beef maintained significantly lower average shear values (more tender) compared to those samples without tumbling (Table 3). It indicated that tumbling still causes roast beef to be more tender, even though there was no salt or phosphate added. The shear values of treatments were significantly increased at day 7 when compared to day 0 as would be expected (Table 3). There was no significant difference between roast beef with different ascorbic acid levels added (Tables 3).

Table 3 Main effect for TBARS values, pH, moisture, shear values, total iron, heme iron and nonheme iron of roast beef

Main effect Concentration of ascorbic acid	TBARS values	pH	Moisture	Shear values (kg)	Total iron (µg/g)	Heme iron (µg/g)	Nonheme iron (µg/g)
0			49.92	4.32	46.19	22.66	23.53
550ppm			49.84	4.30	45.13	22.83	22.02
1000ppm			50.37	4.42	44.85	23.46	21.67
5000ppm			49.15	4.21	44.58	23.49	20.97
Tumbling							
NonTumbled	0.58	5.69	49.98	4.55^{a}	45.45	23.23	22.22
Tumbled	0.55	5.68	49.66	4.08^{b}	44.92	22.99	21.87
Storage Time							
Day 0			50.65^{W}	3.98^{X}	44.30	23.81	20.49^{X}
Day 2			50.10^{W}	4.16^{X}	44.43	23.13	21.20^{X}
Day 4			49.72^{WX}	4.35^{X}	45.46	22.99	22.47^{WX}
Day 7			48.82^{X}	4.76^{W}	46.55	22.52	24.03^{W}

[ab] Means with different lowercase superscripts within a column, within main effect of tumbling are significantly different ($p<0.05$)

[WXYZ] Means with different uppercase superscripts within a column, within main effect of storage time are significantly different ($p<0.05$)

Table 4 TBARS values (mg of malonaldehyde /kg of muscle) of roast beef during refrigerated storage due to ascorbic acid level and storage time

Concentration of ascorbic acid	Storage time, days			
	0	2	4	7
0	0.24^{I}	0.71^{CD}	0.81^{BC}	1.10^{A}
550ppm	0.35^{GHI}	0.48^{EFG}	0.53^{EF}	0.86^{B}
1000ppm	0.38^{GH}	0.47^{EFG}	0.58^{DE}	0.85^{B}
5000ppm	0.29^{HI}	0.40^{FGH}	0.45^{EFG}	0.57^{DE}

[ABCDEFGHI] All means with different uppercase superscripts are significantly different ($p<0.05$)

For total iron and heme contents, there was no significant difference due to ascorbic acid, concentration, tumbling, and storage time for roast beef (Table 3). For nonheme iron, there was no significant difference of ascorbic acid levels and tumbling, but it indicated that nonheme iron values were significantly increased at day 7 compared to that at day 0 (Table 3).

There was no significant two-way (concentration x tumbling) of psychrotrophile, mesophile and thermophile. Therefore, main effects are discussed as follows. Treatment with 0 ppm of ascorbic acid had significantly higher value for psychrotrophile; but, there was an insignificant difference between nontumbled and tumbled samples (Table 1). There was no significant difference due to concentration of ascorbic acid and tumbling for mesophile and thermophile (Table 1). According to table 1, it indicated that the injection of 5000ppm of ascorbic acid inhibited bacteria growth in refrigerated storage.

Conclusions

The oxidation stability of roast beef was dependent on the concentrations of ascorbic acid. The high levels of added ascorbic acid in treatments effectively reduced TBARS values. This suggests that the function of adding ascorbic acid could act as an oxygen scavenger to decrease the speed of lipid oxidation when tumbled in a non-vacuum environment.

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