Effects of electrical stimulation on lipid oxidation and warmed-over flavor of roast beef

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Background

Tims and Watts (1958) were the first researchers to describe warmed-over flavor (WOF) as the undesirable flavor of cooked meat during short-term refrigerated storage. Recently, many researchers have indicated a lot of reactions, including lipid oxidation, involved in the development of undesirable flavor in meat (Spanier *et al.*, 1988; St. Angelo *et al.*, 1988). Meat flavor deterioration (MFD) is currently used to describe this undesirable flavor (Spanier *et al.*, 1988). However, autoxidation, which is a continuous free radical chain reaction (Pearson *et al.*, 1983), is still hypothesized as the major reaction responsible for WOF of precooked roast beef. WOF makes it difficult to introduce precooked beef products as convenience foods into the market place.

A lot of processes damage the structure of meat products that would contribute to lipid oxidation and WOF in precooked beef. Electrical stimulation (ES) causes contraction of muscle and improves the tenderization process. Disruption of muscle structures could promote lipid oxidation and increase the off-flavor problem in meat.

Objectives

The objectives of this study were to evaluate the rate of lipid oxidation or warmed-over flavor that could be affected by electrical stimulation of precooked roast beef after refrigerated storage and to seek the optimum quality of precooked roast beef from the lipid oxidation and warmed-over flavor standpoint.

Methods

A low voltage (40 volts) was used to stimulate the carcass. All beef round primal cuts were cut into uniform cubes (8x8x8 cm) of roasts and then roasts were cooked with a hot-air convection oven until the internal temperature reached 160°F (71°C). Moisture content, pH values and crude fat contents were evaluated for compositions of raw material (Ockerman, 1985). A modified extraction of the TBARS method was analyzed for lipid oxidation (Pensel, 1990). The results of electrical stimulation were evaluated by yields, Warner-Bratzler shear value (Ockerman, 1985), and sensory test. A triangle test and a descriptive analysis followed the modified procedures of Love (1988), St. Angelo *et al.* (1988), and Meilgaard *et al.* (1991). Total aerobic, psychrothrophic, and thermophilic bacteria tests were utilized to detect contamination of various bacteria in precooked roast beef (Speck, 1984).

A randomized complete block design was utilized in this research. A general linear model (GLM) was analyzed by the Statistical Analysis System (SAS Institute, Inc., 1999). Multiple comparisons of significant differences were determined by Duncan's multiple range at $\alpha = 0.05$.

Results & Discussion

There was no significant difference ($P>0.05$) of moisture content and fat content between non-electrically stimulated (nonES) beef bottom round and electrically stimulated (ES) fresh samples. However, ES fresh roast beef had significantly ($P<0.05$) lower pH value when compared to nonES samples as would be expected. Stimulation significantly decreased pH of fresh meat because ES has been reported (Dutson *et al.*, 1980; Ockerman and Szczawinski, 1983) to increase the pH decline. Yields of nonES and ES roast beef were not significantly different ($p>0.05$). Basically, electrical stimulation did not change the composition of roast beef significantly.

The pH values of precooked roast beef had a significant two-way interaction ($p<0.01$) between stimulation and days; that is, the effect of electrical stimulation on pH was dependent on storage days. NonES precooked roast beef maintained the same pH up to 4 days of refrigerated storage ($P>0.05$); however, the pH of ES roast beef significantly increased ($p<0.05$) during 4 days of storage (Table 1). At day 0, cooked ES roast beef had significantly ($p<0.05$) lower pH than NonES as would be expected, but ES had higher pH at day 4 ($p<0.05$).

For lipid oxidation (Table 2), TBARS values of NonES and ES were significantly increased ($p<0.05$) during 4 days of refrigerated storage, but there was no stimulation effect ($P>0.05$). The electrical stimulation could release catalyses to promote lipid oxidation by disrupting muscle structure. However, the cooking process also releases a great amount of catalyses by muscle denaturation and would promote chemical oxidation; therefore, the stability of lipid oxidation is relatively less influenced by stimulation (40 volts) when it is compared to the high temperature of roasting (71°C).

At day 0, only three panelists discriminated treatments correctly by the triangle test. Therefore, there was no significant difference between the two treatments because a significance ($\alpha=0.05$) only occurs when at least five out of a six panel members have the correct answers (Meilgaard *et al.*, 1991). Comparisons of WOA, WOF (Table 2), and tenderness scores indicated that there was no significant difference for NonES and ES. WOA scores of both treatments did not significantly change, but WOF scores significantly increased ($p<0.05$) and tenderness scores significantly decreased ($P<0.05$) during storage.

RBF was influenced by electrical stimulation and was dependent on storage time. From day 2 to day 4 in refrigerated storage at 4°C, precooked roast beef without ES did not significantly change; however, ES had a significantly ($P<0.05$) decreasing score during the same period (6.06 dropped to 4.83). That is the reason ES had significant ($P<0.05$) lower RBF score than NonES at day 4 (Table 1). Sekikawa *et al.* (1999) indicated that ES increased the content of free amino acids due to protein degradation via proteases and other enzymes during this process. One amino acid, such as alanine, was decreased slightly during storage compared to the non-electrically stimulated treatment. There was no significant ($P>0.05$) difference in this research due to stimulation as measured by TBARS and sensory test (WOF and WOA). But, electrical stimulation did cause a decrease of desirable roast beef flavor probably due to complicated reactions of other materials such as amino acids.

Shear values (Table 2) indicated that stimulation produced a significantly ($P<0.01$) more tender precooked roast beef when compared to NonES. However, the trained panel did not detect this difference in tenderness. It could be that the objective method is more sensitive than the subjective tenderness evaluation and also low voltage stimulation was utilized in this study that is often not as effective at increasing tenderness as high voltage stimulation.

Bacterial counts were numerically lower for electrical stimulation tissue, but did not significantly change the mesophile, thermophile, and psychrophile growth in precooked roast beef at day 7. Ockerman and Szczawinski (1983) reported a reduction of microflora by ES that became less significantly important in an inoculated beef tissue with storage time.

Conclusion

There was no significant difference between chemical compositions and cooking yields between the control (NonES) and the electrically stimulated (ES) roast beef. TBARS and sensory test (WOA and WOF) shows that electrical stimulation had no significantly effect on oxidative stability and off-flavor problems of precooked roast beef. Aslo, there was an increased undersirable WOF and a decrease in tenderness for both ES and NonES treatments over time. The electrical stimulation could cause a significantly ($P<0.05$) less desirable roasting flavor after 4 days of storage that may be caused by reactions of amino acids or other compounds in cooked meat.

References

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Table 1 Effect of electrical stimulation on pH values and roast beef flavor scores of precooked roast beef during refrigerated storage

	Days		
PH values	0	2	4
NonES[1]	5.88^{a}	5.87	5.92^{b}
ES[1]	5.79^{Cb}	5.88^{B}	5.98^{Aa}
RBF[1]			
NonES	NE[1]	5.88^{Aa}	6.06a^{Ab}
ES	NE	6.06^{Aa}	4.83b^{Ba}

[1] NonES= non-electrically stimulated; ES= electrically stimulated; RBF= roast beef flavor score evaluated by the trained panel; NE= not evaluated

^{ABC} Means with different uppercase superscripts within the same row of one measurement are significantly different ($p<0.05$); ^{a,b} Means with different lowercase superscripts within the same column of one measurement are significantly different ($p<0.05$)

Table 2 Main effect of electrical stimulation or time on TBARS values, shear values, WOA, WOF and tenderness of precooked roast beef

Main effect	TBARS value (mg/kg)	Shear value (Kg)	WOA[1]	WOF[1]	Tenderness[1]
Stimulation					
NonES	0.50^{A}	4.39^{A}	4.09^{A}	4.54^{A}	5.89^{A}
ES	0.46^{A}	3.59^{B}	3.53^{A}	4.22^{A}	6.53^{A}
Time					
0	0.28^{c}	2.99^{c}	NE	NE	NE
2	0.45^{b}	3.99^{b}	3.71^{a}	3.94^{b}	6.63^{a}
4	0.71^{a}	5.00^{a}	3.89^{a}	4.81^{a}	5.81^{b}

[1] WOA= warmed-over aroma score; WOF= warmed-over flavor score; Tenderness= tenderness score evaluated by the trained panel

^{AB} Means with different uppercase superscripts within main effect of stimulation are significantly different ($p<0.05$)

^{a,b,c} Means with different lowercase superscripts within main effect of time are significantly different ($p<0.05$)