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OPTIMAL SYSTEMS FOR RAPID PROCESSING OF BEEF

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ABSTRACT

THE U. S. Department of Agriculture has been investigating electrical stimulation coupled with hot processing for the past 3 years. The research focused on systems for marketing young and mature beef from electrically stimulated hot processed beef carcasses. Research included studies of the effects of excision time postmortem, electrical stimulation treatments, storage methods and USDA grade on the physical, chemical and sensory properties of primal cuts and ground beef. The results of the various studies are summarized by the following conclusions. Hot processed ground beef was superior to chilled ground beef in palatability, cooking properties and shelf-life. Hot processed vacuumized primal cuts had less weight loss during storage, and shape and appearance were equivalent to cold boned cuts. As postmortem boning time increased, cooking losses also increased. Postmortem electrical stimulation allowed early boning and rapid chilling of primal cuts without toughening of the muscle.

INTRODUCTION

THE HOT processing of prerigor muscles, followed by vacuum packaging, has several potential advantages. When only the edible muscle and fat are removed prerigor, refrigeration space and costs are minimized, processing labor is decreased, and storage yields increased (Cross et al., 1980a, and Fergus & Henrickson, 1979). Several studies have involved the effect of hot, or early, processing on the tenderness of beef muscle (Schmidt and Gilbert, 1970; Kastner et al., 1973; Gilbert and Davey, 1976; Gilbert, Davey and Newton, 1976; Cross et al., 1980b; Cuthbertson, 1977). Kastner et al. (1973) excised beef muscles at 2, 5 and 8 hr postmortem and found it was necessary to hold the sides for 8 hr before boning. Muscles removed at 2 or 5 hr were significantly tougher than the control sides. Gilbert and Davey (1976) used electrical stimulation to accelerate the onset of rigor mortis to allow early boning of beef muscles. It appears that, with electrical stimulation postmortem, carcasses may be processed soon after death. Several factors should be evaluated before the concept may be put into use. This review will present some results and conclusions from four separate USDA studies on electrical stimulation and hot processing.

MATERIALS AND METHODS

STUDY 1: Sensory and cooking properties of ground beef prepared from hot and chilled beef carcasses.

At 3 hr postmortem, the semimembranosus and longissimus muscles were removed from one side of each hot carcass, while at 24 hr postmortem, the same muscles were removed from the opposite chilled sides and used for another study. The remainder of the meat from the carcass was used for ground beef patties. Hot processed ground beef was prepared from 24 unstimulated U.S. Utility carcasses by one of the following three grinding methods: (1) initial break with kidney plate followed by 0.3 cm final grind; (2) initial break with kidney plate, followed by 1.3 cm grind and 0.3 cm final; and (3) same as No. 2 except that the formulation contained no chilled U.S. Choice plates. Chilled muscle (control) was ground through a 1.3 cm plate followed by a 0.3 cm final grind. Sensory properties of ground beef were determined with a trained sensory panel as outlined by AMSA (1978) and Cross et al. (1978). Patties were broiled 12 min on electric Farberware Grills.

STUDY 2: The effect of electrical stimulation and postmortem excision time on sensory and cooking properties of ground beef.

Twenty-four U.S. Utility carcasses were used to prepare the hot and chilled ground beef using grinding procedures similar to Study 1. Ground beef was prepared from electrically stimulated and non-stimulated sides that were processed at 1, 3 or 24 hr postmortem. Sides were stimulated within 45 min postmortem by passing a constant 1.5 amp of current AC (60Hz) through the carcass (150-300v) for 3 min with four 10 sec shocks per min. Sensory and cooking techniques were identical to those in Study 1.

STUDY 3: Storage properties of primal cuts of hot and cold processed beef.

One side from each of ten carcasses was selected for electrical stimulation and hot-processing within 1 hr postmortem while the opposite side was chilled for 48 hr at 2-3 C before boning. Ten boneless primal cuts were removed from the hot- and cold-processed sides. Each cut was evaluated for lean color, fat color and shape. Hot and cold processed cuts were vacuumized and stored for 20 days at 2-3 C. After the storage period, all cuts were again evaluated for lean and fat color and shape. Weight loss during storage was calculated for each cut.

STUDY 4: Accelerated processing systems for USDA Choice and Good beef carcasses.

Seventy-two sides from 36 Choice and Good grade carcasses were used to study the effects of USDA grade, postmortem excision time, storage method, and electrical stimulation on the quality traits, storage properties, chemical traits and sensory ratings of the longissimus muscle. Excision times were 1, 4 or 48 hr, while storage methods were (a) vacuum package and immediate freeze at -40 C; (b) vacuum package, chill 24 hr and freeze at -40 C; and (c) vacuum package, chill 20 days and freeze at -40 C. Sensory methods were identical to Study 1. Steaks were broiled (2.5 cm thick) to 70 C internal temperature. Other variables included initial, frozen and final pH; water-holding capacity; thaw and cooking loss; fat and moisture; cooking time; and degree of doneness.

RESULTS and DISCUSSION

STUDY 1. Method of grinding had no significant effect on sensory and cooking properties of ground beef, thus the data for hot ground beef is combined and presented in table 1. Ground beef patties prepared from hot-processed beef were significantly (P<.05) more tender, more juicy and lost less weight during cooking. Treatment did not significantly affect the amount of panel detectable connective tissue or flavor intensity (data not presented). Hot-processed patties changed significantly less in diameter than chilled patties. Percent fat and water did not differ (P<.05) in the raw patty and percent fat did not differ in cooked patty. Percent moisture in the cooked patties was higher (P<.05) from hot patties and can be explained by the differences in cooking loss.

Table 1. Study 1. The effect of processing on sensory, chemical and physical traits of ground beef patties.

Trait	Type of Processing: Hot		Chilled
Tenderness[a]	5.7	*	5.2
Juiciness[b]	5.5	*	4.8
Cooking loss, %	33.9	*	41.1
Diameter change, %	14.9	*	19.3
Height change, %	16.0	NS	14.0
H_2O, raw, %	62.1	NS	62.3
Fat, raw, %	20.0	NS	19.6
H_2O, cooked, %	52.1	*	48.6
Fat, cooked, %	21.1	NS	21.8

[a] 8 = extremely tender and 1 = extremely tough.

[b] 8 = extremely juicy and 1 = extremely dry.

* P<.05.

NS = not significantly different.

STUDY 2. Research from this Laboratory (Study 4) indicates that carcasses must be electrically stimulated prior to hot processing or the steak and roast cuts may be unacceptably tough. The possibility exists for postmortem electrical stimulation (ES) to have negative effects on the cooking properties of ground beef because of the rapid pH decline. The effects of ES and excision time on sensory and cooking properties is summarized in table 2. Postmortem ES had no negative effects on the chemical, physical, sensory or cooking properties of ground beef patties. Postmortem excision time had significant effects on percent height change during cooking, total cooking loss, tenderness and juiciness. As excision time increased, the effects on the aforementioned traits were negative.

Table 2. Study 2. Sensory, chemical and cooking properties of beef patties as influenced by electrical stimulation and excision time.

Trait	Postmortem excision time, hr. 1: Shock treatment[a]		3: Shock treatment[a]		24: Shock treatment[a]	
	ES	NS	ES	NS	ES	NS
pH, initial	6.2^{d}	6.6^{c}	5.8^{e}	6.2^{d}	5.5^{e}	5.7^{e}
pH, frozen	5.6^{c}	5.7^{c}	5.5^{c}	5.6^{c}	5.4^{c}	5.5^{c}
pH, thawed	5.6^{c}	5.6^{c}	5.6^{c}	5.6^{c}	5.5^{c}	5.5^{c}
Diameter change, %	21.4^{cd}	18.7^{de}	17.1^{e}	19.4^{d}	20.2^{d}	22.1^{c}
Height change, %	9.0^{d}	8.7^{d}	16.4^{c}	14.5^{c}	13.7^{c}	13.4^{c}
Cooking loss, %	40.5^{d}	36.0^{d}	41.7^{d}	40.2^{d}	43.9^{c}	44.4^{c}
Tenderness[b]	5.2^{cd}	5.5^{c}	5.1^{de}	5.1^{de}	4.8^{ef}	4.6^{f}
Juiciness[b]	5.7^{c}	5.7^{c}	5.4^{c}	5.9^{c}	4.5^{f}	4.1^{f}
Instron work	65.3^{c}	61.9^{cd}	66.1^{c}	61.7^{cd}	60.7^{cd}	57.4^{d}

[a] ES = electrically stimulated and NS = not stimulated.

[b] 8 = extremely tender and juicy, and 1 = extremely tough and dry.

c-f means in the same row with different superscripts are different (P<.05).

STUDY 3. The storage properties of hot and cold-processed beef primals are summarized in table 3 as the mean of ten primal cuts. After 20 days of storage, hot- and cold-processed cuts did not differ (P<.05) in lean color. Hot-processed cuts had fat that was whiter (P<.05) than that of cold-processed cuts. Cold-processed cuts were more nearly normal in shape (rating of 6 or higher) than were hot-processed cuts; whereas, hot cuts retained their vacuum better and lost considerably less weight during storage than did cold-processed cuts.

Table 3. Study 3. Chemical and physical properties of hot and cold-processed beef primals.

Trait (Avg. of 10 cuts)	Type of processing: Hot-processed 1 hr		Cold-processed 48 hr
Initial pH	6.1	**	5.7
Initial lean color[a]	2.8	*	5.5
20 day lean color[a]	3.5	NS	3.8
Initial fat color[b]	3.3	*	2.9
20 day fat color[b]	3.8	*	3.1
Initial shape[c]	6.6	*	7.7
20 day shape[c]	6.4	*	7.0
Leakage rating[d]	5.0	**	7.7
Storage loss, %[e]	0.29	**	1.02

[a]8=light greyish-red and 1=very dark red or purple.

[b]5=white and 1=yellow.

[c]8=normal and 1=extremely abnormal.

[d]15=extreme leakage or loss of vacuum and 1=no visable leakage or loss of vacuum.

[e]Storage loss calculated as percent weight loss during 20 days of storage.

*Different at the P<.05 level.

**Different at the P<.01 level.

STUDY 4. Electrical stimulation had no significant effect on lean firmness, lean texture, heat ring or marbling (data not presented). Carcass grade had no significant effect on quality traits of the longissimus muscle (data not presented). The effects of postmortem excision time on quality traits are presented in table 4. Postmortem excision time had significant effects on storage loss and leakage ratings of the vacuum bag. Ratings were most favorable when sides were processed soon after slaughter. Muscles excised at 48 hr were more tender than those boned at 1 or 4 hr; however, as the time between slaughter and processing increased, the percentage of cooking loss increased.

The effects of storage method and ES are summarized in table 5. Muscles that were frozen immediately or before 24 hr were borderline in tenderness. Electrical stimulation increased the tenderness of these muscles but not enough that their tenderness equaled that of muscles aged 20 days. Freezing muscles immediately would involve some tenderness risk, even with ES. With ES, muscles can be frozen after 24 hr.

Table 4. Study 4. Effect of postmortem excision time and physical, sensory and cooking properties of the beef longissimus muscle.

Trait	Postmortem excision time, hr: 1	2	48
Initial LD temp, C	33.3[e]	22.4[d]	-1.2[e]
Storage loss, %	0.8[d]	1.2[cd]	1.7[c]
Leakage rating[a]	4.3[c]	7.1[cd]	9.0[e]
pH, initial	6.3[c]	6.0[d]	5.5[e]
Cooking loss, %	32.4[c]	34.6[d]	34.7[d]
Tenderness[b]	5.5[c]	5.3[cd]	5.8[e]
Juiciness[b]	5.3[c]	5.2[c]	5.4[c]
Shear force, kg	7.6[c]	6.7[d]	5.4[e]

[a]15=extreme leakage or loss of vacuum and 1=no visable leakage or loss of vacuum.

[b]8=extremely tender and juicy and 1=extremely tough and dry.

[c-e]Means in the same row with different superscripts are different (P<.05).

Table 5. Study 4. Effect of postmortem storage treatments on physical, sensory and cooking properties of the beef longissimus muscle

Trait	Postmortem Storage Treatments[a]: Freeze ES[b]	Freeze NS[b]	Chill 24 hr and freeze ES[b]	Chill 24 hr and freeze NS[b]	Chill 20 days and freeze ES[b]	Chill 20 days and freeze NS[b]
pH, initial	5.9[d]	6.1[e]	5.7[d]	6.2[e]	5.7[d]	6.1[e]
Cooking loss, %	35.6[de]	33.1[de]	33.9[de]	36.0[d]	31.1[e]	33.6[e]
Thaw loss, %	1.7[ef]	2.9[d]	2.9[d]	2.3[de]	0.9[f]	0.8[f]
Water holding capacity, %	54.6[e]	56.5[ef]	58.6[def]	60.0[de]	62.6[d]	62.7[d]
Tenderness[c]	5.3[g]	5.0[h]	5.6[f]	4.1[i]	6.8[d]	6.3[e]
Juiciness[c]	5.3[d]	5.4[d]	5.3[d]	5.0[d]	5.4[d]	5.4[d]
Shear force, kg	7.4[e]	7.4[e]	7.4[e]	7.8[d]	3.8[g]	4.6[f]

[a]Freeze=vacuum packaged, frozen at -40 C on racks for 24 hr and stored in boxes at -4 C; Chill and freeze=vacuum packaged, chilled on racks for 24 hr at 2 to 3 C, moved to boxes, and frozen at -40 C; Chill 20 days and freeze=vacuum packaged, chilled on racks for 24 hr at 2 to 3 C, moved to boxes and stored 20 days at 2 to 3 C, and frozen at -40 C.

[b]ES=electrically stimulated and NS=not stimulated.

[c]8=extremely tender and juicy, and 1=extremely tough and dry.

[d-i]Means in the same row with different superscripts are different (P<.05).

Conclusions (Studies 1-4)

1. Hot-processed ground beef is equal to or superior to cold-processed ground beef in physical, chemical, cooking and sensory properties.
2. As postmortem excision time increases, storage and cooking losses increase.
3. ES has no negative effect on ground beef quality traits.
4. Hot-processed primal cuts have superior storage properties when compared to cold-processed cuts.
5. Muscle frozen immediately or before 24 hr were borderline in tenderness.
6. With ES, muscles can be removed from the carcass within 1 hr postmortem and frozen after 24 hr.

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