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ULTRASOUND VERSUS CONVECTION COOKING OF BEEF LONGISSIMUS AND PECTORALIS MUSCLES

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Summary

Longissimus and pectoralis muscles were removed from 10 steer carcasses at 4 days postmortem, aged for 14 days at 4°F, then assigned to either ultrasound (ULS) or convection (Conv) cooking to either 144 or 158°F internal temperature. Ultrasound cooking was faster (P<.05), had greater (P<.05) moisture retention and less (P<.05) cooking loss, and used less energy (P<.05). It also produced muscle samples that required less (P<.05) peak force to shear than those from Conv cooking and resulted in superior (P<.05) myofibrillar tenderness. No significant interactions occurred among cooking method, muscle, or endpoint temperature. As expected, longissimus (ribeye) muscles cooked faster (P<.05) and required less (P<.05) energy and were superior (P<.05) in instrumentally measured texture and sensory tenderness than pectoralis muscles. Cooking to 158°F caused greater (P<.05) moisture and cooking losses, required more (P<.05) time and energy, and degraded (P<.05) instrumental textural and sensory characteristics. Ultrasound offers a new cooking mode that could increase cooking speed, improve energy efficiency and improve some textural characteristics, compared to conventional cooking.

(Key Words: Beef, Ultrasound Cooking, Endpoint Temperature, Tenderness.)

Introduction

Although numerous techniques have been used to cook meat, variability in cooking time, energy consumption, and palatability provide obstacles for universal use of any single technique. Microwave cooking provides fast heating and superior energy efficiency, but lower cooking yields and less tender and flavorful meat than conventional techniques. Ultrasound (ULS) also can heat muscle, and apparatuses have been developed for ULS cooking of foods and tenderizing meat. Our objective was to compare the effects of ULS and convection cooking to two endpoint temperatures on cooking characteristics and textural and sensory properties of a beef locomotion (pectoralis) and a support (longissimus) muscle.

Experimental Procedures

Deep pectoralis (brisket) and longissimus thoracic (rib cut) muscles were removed from the right sides of 10 Select and Choice steer carcasses at 4 days postmortem, vacuum packaged, and aged at 4°F for a total of 14 days. After aging, muscles were sliced into .4×3.0×3.0 in. sections and individually vacuum packaged; and muscles within each carcass were assigned randomly to treatments. Treatments were arranged in 2×2×2 factorial design with two cooking methods (high intensity ultrasound or Farberware® "Open Hearth" electric convection broiler), two muscle types (deep pectoralis and longissimus thoracic), and two internal endpoints (144 and 158°F) as main

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effects. The ULS cooking was accomplished by placing single, unpackaged, meat sections into a water-filled chamber and applying an ultrasonic field using a Tekmar® Sonic Disrupter, operating at 20 kHz and 1000 W. Convection (Conv) cooking was performed with a Farberware electric broiler. A utility watt meter was connected to both instruments to monitor energy use during cooking and preheating (Conv only). After cooking, muscles were evaluated for Lee-Kramer shear force using an Instron® Universal Testing Machine. Before shearing, cooked meat pieces were cooled to room temperature and weighed to determine cooking losses and to standardize shear force values to a per-gram-of-meat-sheared basis. Peak force (kg/kg sample) and peak force work were determined by shearing perpendicular to the muscle fiber orientation. Flavor and texture were evaluated by trained sensory panelists. Analysis of variance was used to determine treatment effects for this 2×2×2 factorial, randomized, complete block, experimental design. Because no interactions occurred, only main effect means are presented.

Results and Discussion

Because of greater (P<.05) moisture retention (Table 1), ULS cooking resulted in a 60% advantage (P<.05) in cooking yield. Cooking time was nearly double (P<.05) for Conv vs. ULS cooking and required nearly twice the energy (P<.05). Because Conv cooking also required preheating, it was even less efficient (P<.05) when total energy use was considered. Ultrasound cooks efficiently because energy is directed to the muscle being cooked, and less is lost to the environment. Also, ULS cooking is uniform because the intense agitation of the liquid medium by sound wave pressures results in an even distribution of heat.

Cooking loss percentage (Table 1), after adjustment for sample weight, did not vary (P>.05) between muscle types. Longissimus muscles required less (P<.05) cooking time on a cooked, weight-constant basis. Cooking to 144°F internal temperature resulted in less (P<.05) cooking loss, more (P<.05) retained moisture, less (P<.05) cooking time, and, thus, less total energy than cooking to 158°F. No difference (P>.05) was observed between ULS and Conv treatments for peak force to shear samples, when adjusted to per-gram-of-muscle basis (Table 2). However, peak force work was lower (P<.05) for the ULS-cooked samples, which may have been related to the higher (P<.05) postcooking moisture content. As expected, pectoralis muscle required more (P<.05) peak force and peak force work to shear than longissimus muscles (Table 2) because of the higher (P<.05) content of connective tissue (Table 1). Muscles cooked to 158°F required more (P<.05) peak force to shear than samples cooked to 144°F; however, no difference (P>.05) was observed in peak-force work to shear (Table 2).

Sensory panelists detected more charbroiled and beef flavor with Conv cooking (Table 2), probably because of the dry heat. Moist heat ULS cooking not only inhibited development of charbroiled flavor, but also may have extracted beef flavor components into the discarded liquid medium. Greater moisture retention (Table 1) also might have diluted the natural flavor compounds. Although ULS-cooked muscles contained more postcooking moisture, no difference (P>.05) occurred in sensory juiciness between cooking methods. However, sensory panelists indicated more tender (P<.05) myofibrils with ULS cooking. Connective tissue amount and overall tenderness scores were unaffected (P>.05) by cooking method.

Cooked pectoralis and longissimus muscles had similar (P>.05) charbroiled flavor intensity, beef flavor intensity, and juiciness (Table 2). However, sensory panelists found that pectoralis muscles had less (P<.05) myofibrillar tenderness (slightly tender), connective tissue amount (moderate), and overall tenderness (slightly tough) than longissimus muscles. Charbroiled flavor and beef flavor intensity did not differ (P>.05) between the 144 and 158°F treatments (Table 2). Sensory panelists rated the 144°F treatment more (P<.05) juicy and having more (P<.05) myofibrillar tenderness but found no difference (P>.05) in either connective tissue amount or overall tenderness.

Because sensory properties were not impacted severely, ULS may have advantages in speed and energy efficiency for commercial cooking or precooking. Possible uses of ULS include moist heat precooking or cooking of meat cuts destined for prepared meals. Liquid media such as gravies, sauces, or soups would be ideal for coupling ULS energy with the meat. Liquid media also would enhance meat textural characteristics and cooked product yields, especially for lower quality cuts containing more connective tissue. Other possible ULS applications might be as in-home cooking devices. Ultrasound would allow convenient, rapid, meal preparation without detrimental effects on meat texture.

Table 1. Effects of Cooking Method, Muscle, and Endpoint Temperature on Beef Muscle Cooking Characteristics and Energy Consumption

	Cooking Method		Muscle		Endpoint Temperature	
Characteristic	Ultrasound	Convection	Pectoralis	Longissimus	144°F	158°F
Moisture, %	68.0^{a}	62.1^{b}	66.3^{a}	63.8^{b}	66.1^{a}	64.0^{b}
Cooking loss, % [c]	14.7^{a}	23.9^{b}	20.0	18.5	16.4^{a}	22.1^{b}
Cooking time, min	6.7^{a}	12.3^{b}	10.1	9.1	8.5^{a}	10.7^{b}
Preheat energy, watt [e]	$.00^{a}$	2.01^{b}	$.89^{a}$	1.11^{b}	$.93^{a}$	1.08^{b}
Cooking energy, watt [f]	3.8^{a}	7.07^{b}	5.72	5.16	4.85^{a}	6.04^{b}
Total energy, watt [f]	3.8^{a}	9.07^{b}	6.65	6.24	5.78^{a}	7.11^{b}

[a,b] Means within cooking method, muscle, or endpoint temperature bearing different superscript letters differ (P<.05).
[c] Calculated as [1–(cooked wt/fresh wt)] × 100.
[d] Energy consumed during preheating mode.
[e] Energy consumed during cooking mode.
[f] Energy consumed during cooking plus preheating modes.

Table 2. Effects of Cooking Method, Muscle, and Endpoint Temperature on Instrumental Textural Properties and Sensory Panel Evaluations

	Cooking Method		Muscle		Endpoint Temperature	
Characteristic	Ultrasound	Convection	Pectoralis	Longissimus	144°F	158°F
Peak force, kg/g sample	10.0	10.7	56.8^{a}	28.4^{b}	9.8^{a}	10.8^{b}
Peak force work [c]	40.0^{a}	45.2^{b}	130.7^{a}	70.7^{b}	41.8	43.3
Charbroiled flavor intensity [d]	1.2^{a}	1.7^{b}	1.5	1.3	1.4	1.4
Beef flavor intensity [d]	4.9^{a}	5.9^{b}	5.4	5.4	5.4	5.4
Juiciness [e]	6.0	6.1	6.1	6.0	6.2^{a}	5.9^{b}
Myofibrillar tenderness [f]	6.2^{a}	5.8^{b}	5.3^{a}	6.7^{b}	6.1^{a}	5.9^{b}
Connective tissue amount [g]	5.7	5.5	4.1^{a}	7.1^{b}	5.6	5.6
Overall tenderness [f]	5.7	5.4	4.3^{a}	6.8^{b}	5.6	5.4

[a,b] Means within cooking method, muscle, or endpoint temperature bearing different superscript letters differ (P<.05).
[c] Peak force work (energy) to shear samples in units of kg force/unit area under plotter curve.
[d] 1 = extremely bland, 4 = slightly bland, 8 = extremely intense.
[e] 1 = extremely dry, 4 = slightly dry, 8 = extremely juicy.
[f] 1 = extremely tough, 4 = slight tough, 8 = extremely tender.
[g] 1 = abundant, 4 = moderate, 8 = none.