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EFFECTS OF ULTRASOUND AND CONVECTION COOKERY TO DIFFERENT ENDPOINT TEMPERATURES ON BEEF *LONGISSIMUS* AND *PECTORALIS* MUSCLE COOKING AND SENSORY PROPERTIES, SHEAR FORCE , AND MICROSCOPIC MORPHOLOGY

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Background

Numerous techniques have been employed to cook meat. Variations in cooking time, meat palatability, and energy consumption by cooking appliances have provided obstacles for universal use of any single technique. Electronic cookery methods, such as microwave cookery, have provided fast heating rates with superior energy efficiency, but have produced inferior meat cooking yields, and less tender, less juicy, and less flavorful meat than conventional cookery techniques. Unfortunately, conventional cookery techniques also can result in meat palatability problems including less tender, less flavorful and dry meat as well as inferior cooking energy efficiencies compared to other cookery techniques. Therefore, the need exists for a rapid, energy efficient cookery technique that will not cause meat toughening or other negative affects on palatability. One possible new cookery technique might be the use of high intensity ultrasound.

Objectives

Since ultrasound has a heating effect on muscle (Eggleton et al., 1965; Gersten, 1965; Dickens et al., 1991), the objective of our study was to determine the effects of high intensity ultrasound on beef pectoralis and longissimus muscle cooking characteristics, textural and sensory properties, and microscopic morphology.

Methods

Longissimus and pectoralis muscles were removed from 10 A-maturity steer carcasses (4 d postmortem), vacuum packaged, aged for 14 d, then assigned to ultrasound (20kHz, 1000W electrical power) or convection cookery (Farberware "Open Hearth" electric broiler) treatments to either 62C or 70C internal endpoint temperature. Samples cooked with ultrasound were immersed in water to facilitate ultrasonic wave penetration. Time-temperature profiles and energy consumption characteristics were recorded during cookery. Data were analyzed as a 2 (cookery method) x 2 (endpoint temperature) x 2 (muscle type) factorial design within a randomized complete block.

Results and Discussion

The ultrasound cookery technique resulted in less ($P<.05$) cooking loss, greater ($P<.05$) cooking speed, and greater ($P<.05$) efficiency of energy consumption (Table 1). While water immersion during the ultrasound cookery treatment obviously contributed to decreased cooking loss, the ability to focus the ultrasonic waves on muscle samples during cookery provided for increased cooking speed with less energy expended during the cookery process. Therefore, greater quantities of cooked meat result from less energy, time and raw meat inputs. Cooking to 70C compared to 62C caused greater ($P<.05$) moisture and cooking losses, and required more ($P<.05$) time and energy input to cook (Table 1). Ultrasound cooked muscles required less ($P<.05$) instrumental peak-force work to shear, retained more ($P<.05$) moisture, had a lower ($P<.05$) proportion of soluble collagen, scored less intense ($P<.05$) for sensory beef flavor, and more tender ($P<.05$) for sensory myofibrillar tenderness (Table 2). The improved instrumental and sensory tenderness properties of the ultrasound cooked muscles compared to the convection cooked muscles were related to microscopic morphology. Transmission and scanning electron micrographs indicated that ultrasound treated muscles had longer sarcomeres, larger diameter fibers, and more myofibrillar disruption and shattering than the Farberware cooked muscles. No difference ($P>.05$) in instrumental peak shear force, total shear work, or sensory evaluated juiciness, connective tissue amount or overall tenderness were observed between ultrasound and Farberware cooked muscles. Cooking to 70C negatively ($P<.05$) affected instrumental peak force and sensory panel juiciness and myofibrillar tenderness (Table 2). Electron micrographs of muscles cooked to an internal temperature of 70C had shorter sarcomeres, more deterioration of the banding structure, a reduction in fiber diameter, and more breakdown of epimysial and perimysial connective tissue than muscles cooked to 62C internal temperature.

Conclusions

Ultrasound cookery provides a new, rapid, energy efficient cookery technique that may improve beef tenderness and cooking yield but decrease beef flavor intensity.

Literature Cited

Dickens, J. A., C. E. Lyon, and R. L. Wilson. 1991. Effect of ultrasonic radiation on some physical characteristics of broiler breast muscle and cooked meat. Poult. Sci. 70:389.

Eggleton, R. C., E. Kelly, F. J. Fry, R. Chalmers, and W. J. Fry. 1965. Morphology of ultrasonically irradiated skeletal muscle. In: E. Kelly (Ed.) Ultrasonic Energy. pp 117-136. University of Illinois Press, Urbana, IL.

Gersten, J. W. 1965. Biological effects of ultrasound on neuromuscular skeletal systems. In: E. Kelly (Ed.) Ultrasonic Energy. pp 150-159. University of Illinois Press, Urbana, IL.

Table 1. Effects of cookery method or endpoint temperature on beef muscle cooking characteristics and energy consumption

Characteristic	Cookery method: Ultrasound	Cookery method: Farberware	SE	P-value[a]	Endpoint temperature: 62C	Endpoint temperature: 70C	SE	P-value[a]
Cooking loss,%[b]	14.70	23.90	0.70	<.01	16.40	22.10	0.70	<.01
Cooking time, min	6.70	12.30	0.50	<.01	8.50	10.70	0.50	<.01
Cooking time/cooked wt, min/g[c]	0.15	0.30	0.01	<.01	0.19	0.25	0.01	<.01
Preheat cooking energy, watt[d]	0.00	2.01	0.02	<.01	0.93	1.08	0.02	<.01
Cooking energy, watt[e]	3.80	7.10	0.27	<.01	4.85	6.04	0.27	<.01
Total cooking energy, watt[f]	3.80	9.07	0.32	<.01	5.78	7.11	0.32	<.01
Total cooking energy/cooked wt, watt/g[g]	0.08	0.22	0.01	<.01	0.13	0.17	0.01	<.01

[a]Probability that cookery type or endpoint temperature means within the same row differ.
[b]Calculated as (1-(cooked wt/fresh wt))X100.
[c]Cookery time expressed as a function of cooked muscle wt.
[d]Energy consumed during preheating mode.
[e]Energy consumed during cookery mode.
[f]Energy consumed during cookery plus preheating modes.
[g]Cooking energy plus appliance preheating energy expressed as a function of cooked muscle wt.

Table 2. Effects of cookery method or endpoint temperature on beef muscle instrumental textural properties, chemical composition and sensory characteristics

Characteristic	Cookery method: Ultrasound	Cookery method: Farberware	SE	P-value[a]	Endpoint temperature: 62C	Endpoint temperature: 70C	SE	P-value[a]
Peak force, kg/g sample	10.00	10.70	0.40	0.16	9.80	10.80	0.40	0.05
Peak force work[b]	40.00	45.20	1.50	0.02	41.80	43.30	1.50	0.49
Total shear work[c]	97.40	104.00	3.00	0.13	97.40	104.00	3.00	0.13
Moisture, %	68.00	62.10	0.40	<.01	66.10	64.00	0.40	<.01
Soluble collagen, mg/g[d]	0.50	0.60	0.01	0.03	0.60	0.40	0.01	<.01
Beef flavor intensity[e]	4.90	5.90	0.10	<.01	5.40	5.40	0.10	0.33
Juiciness[f]	6.00	6.10	0.10	0.74	6.20	5.90	0.10	0.02
Myofibrillar tenderness[g]	6.20	5.80	0.10	0.01	6.10	5.90	0.10	0.03
Connective tissue amount[h]	5.70	5.50	0.20	0.39	5.60	5.60	0.20	0.99
Overall tenderness[g]	5.70	5.40	0.10	0.14	5.60	5.40	0.10	0.30

[a]Probability that cookery type or endpoint temperature means within the same row differ.
[b]Peak force work (energy) to shear samples in units of kg force/unit area under plotter curve.
[c]Total work (energy) to shear samples in units of kg force/unit area under the plotter curve.
[d]Soluble collagen content in units of mg soluble collagen/g muscle.
[e]1=extremely bland, 4=slightly bland, 8=extremely intense.
[f]1=extremely dry, 4=slightly dry, 8=extremely juicy.
[g]1=extremely tough, 4=slightly tough, 8=extremely tender.
[h]1=abundant, 4=moderate, 8=none.