ENDPOINT TEMPERATURE, COOKING METHOD, AND MARBLING DEGREE HAVE DIFFERENT EFFECTS ON WARNER-BRATZLER SHEAR FORCE OF BEEF LONGISSIMUS LUMBORUM, BICEPS FEMORIS, AND DEEP PECTORALIS MUSCLES

Obuz, E., Dikeman, M. E., Grobbel, J. P., Stephens, J. W., Loughin, T. M.
Kansas State University, Manhattan, KS, USA

Background

Meat tenderness is closely related to meat texture, which in turn is affected by myofibrillar proteins, muscle cytoskeleton, and intramuscular connective tissue and intrafiber water content (Christensen et al., 2000). Davey and Gilbert (1974) reported that meat tenderness decreased in two distinct phases, occurring at temperatures between 40 and 60°C, and 65 and 80°C. They attributed the first increase in meat toughness to heat denaturation of myofibrillar proteins. Bouton and Harris (1972) and Harris and Shorthose (1988) verified that the effects of heating on the connective tissue proteins increased toughness. The second increase in meat toughness was attributed to collagen shrinkage by Davey and Gilbert (1974), but Bouton and Harris (1972) and Harris and Shorthose (1988) explained this toughness by the denaturation of myofibrillar proteins. Due to differences in cooking methodology and shear force measurements we felt it was necessary to evaluate the effects of endpoint temperature, cooking method, and marbling degree on Warner-Bratzler shear force (WBSF) simultaneously.

Objectives

Our objectives were to evaluate the effects of endpoint temperature, cooking method, and marbling degree on WBSF of three different beef muscles.

Methods

Subprimals (boneless strip loin, NAMP (1997) 180; outside round, flat, NAMP 171B; brisket, deckle-off, boneless, NAMP 120) from United States Department of Agriculture Select (low marbling degree) and Choice (Certified Angus Beef, high marbling degree) carcasses were purchased and divided into the respective muscles. Muscles were vacuum packaged and held at 1°C for 14 days and then frozen (-37°C). Each frozen muscle was sawed into 2.54-cm thick steaks, vacuum packaged, and stored frozen until cooking. Steaks were randomized statistically in a split-split plot design to one of two cooking treatments: a Magikitch'n® electric belt grill at 93°C, or a water bath at 93°C; and one of nine endpoint temperatures: 40, 45, 50, 55, 60, 65, 70, 75, or 80°C. Steaks were thawed at 4°C before cooking. The center temperatures of steaks were monitored using copper-constantan thermocouples. Cooked steaks were then refrigerated overnight at 1°C. Six cores were removed parallel to the muscle fiber direction from each steak, and WBSF was measured using an Instron® Universal testing machine. The data were analyzed using the PROC MIXED procedure of SAS (2000).

Results and Discussion

Figure 1 and 2 show the effects of endpoint temperature and marbling degree on WBSF of *longissimus lumborum* (LL) steaks cooked by belt grill and water-bath, respectively. Water-bath cooking resulted in higher ($P<0.0001$) WBSF (3.20 kg) than belt-grill cooking (2.88 kg) for the LL (Table 1). The combination of Select quality grade and cooking to higher endpoint temperatures resulted in higher ($P<0.05$) WBSF for LL (Table 2). For the *biceps femoris* (BF), endpoint temperature was the only significant factor ($P<0.05$) with two distinct phases of tenderization/toughening occurring. Between 40 and 60°C, WBSF decreased from 4.48 kg to 3.89 kg, whereas between 60 and 70°C, WBSF increased from 3.89 kg to 4.53 kg for BF (Figure 3). Water-bath cooking resulted in higher ($P=0.0001$) *deep pectoralis* (DP) WBSF (7.25 kg) than belt-grill cooking (6.04 kg, Figure 4). Endpoint temperature significantly affected ($P<0.0001$) WBSF for DP, evidenced by a strong decline between 45 and 65°C, irrespective of the cooking method. This was followed by an increasing trend in WBSF between 65 and 80°C (Figure 4). Endpoint temperature and cooking method were more important factors than quality grade for the WBSF of the three muscles studied, with quality grade being significant only for LL. In contrast to commonly accepted literature (Bouton and Harris, 1972; Davey and Gilbert, 1974; and Christensen et al., 2000), we did not observe a distinct toughening trend in WBSF between 40 and 50°C for the LL, BF, or DP. However, we observed an increasing trend for WBSF for LL, BF, and DP between 65 and 80°C, but this increasing trend was not as steep as in previous research.

Conclusions

Endpoint temperature and cooking method were more important factors than quality grade for the WBSF of the three muscles studied, with quality grade being significant only for LL. Our results suggest that optimum tenderness for the LL occurs around 55°C and optimum tenderness for the BF and DP occurs between 60 and 65°C. Higher marbling provides insurance for tenderness of the LL at higher endpoint temperatures. More rapid conduction cooking on the Magikitch'n® belt grill resulted in lower WBSF than slower, convection, water-bath cooking for LL and DP. In our study, the effects of increasing endpoint temperature on WBSF of the low connective tissue muscle (LL) were not similar to those of high connective tissue muscles (BF or DP), proving that pertinent literature should be interpreted carefully. Moreover, in most of the previous studies, beef muscles were cooked as small cores in a water-bath at corresponding temperatures for one hour, which is completely different from our cooking system. Our results directly explain the effects of endpoint temperature on WBSF because we cooked our steaks at a constant temperature (constant heating rate), whereas previous results explain the combination of cooking temperature and heating rate on WBSF.

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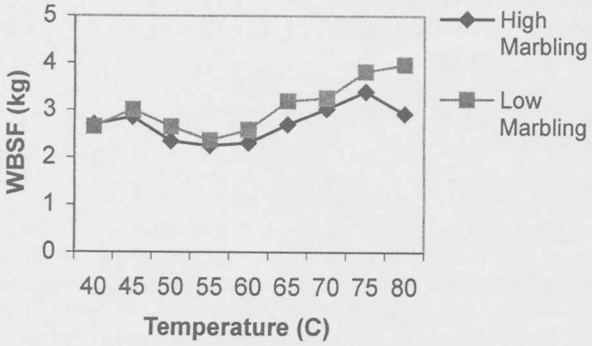

Figure 1. Effects of endpoint temperature and marbling degree (high or low) on Warner-Bratzler shear force (WBSF) of *longissimus* muscle cooked on the belt grill.

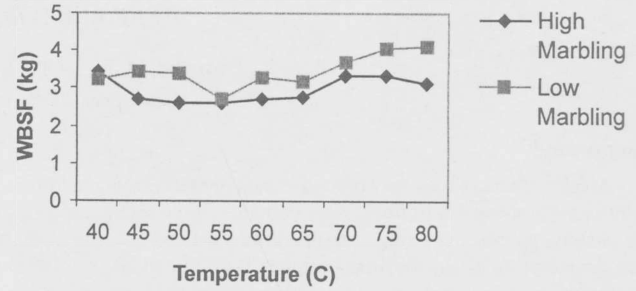

Figure 2. Effects of endpoint temperature and marbling degree (high or low) on Warner-Bratzler shear force (WBSF) of *longissimus* muscle cooked in the water bath.

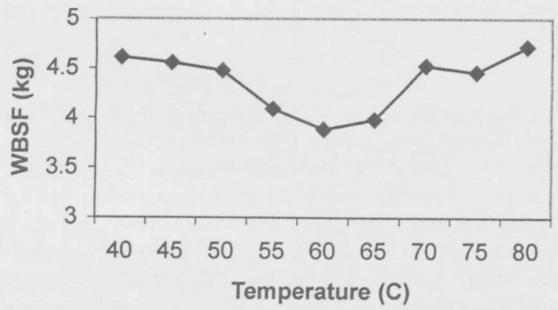

Figure 3. Effects of endpoint temperature on Warner-Bratzler shear force (WBSF) of the *biceps femoris* muscle.

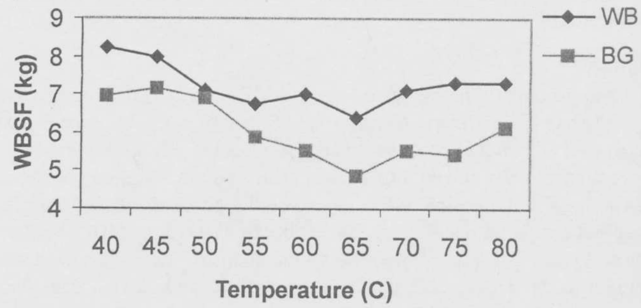

Figure 4. Effects of endpoint temperature on Warner- Bratzler shear force (WBSF) of *deep pectoralis* muscle cooked by belt-grill (BG) or in the water bath (WB).

TABLE 1. Least square means of marbling degree, cooking method, and temperature on Warner-Bratzler shear force (WBSF) of *longissimus* muscle.

Source of Variation	WBSF (kg)	Standard Error
Marbling Degree		
USDA Select (low)	3.25	0.08
USDA Choice (high)	2.83	0.08
P-value	0.001	
Method		
Water bath	3.20	0.07
Belt grill	2.88	0.07
P-value	<0.0001	
Temperature (ºC)		
40	3.00	0.12
45	3.00	0.11
50	2.73	0.12
55	2.48	0.12
60	2.71	0.12
65	2.95	0.11
70	3.32	0.12
75	3.66	0.12
80	3.53	0.12
P-value	<0.0001	

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TABLE 2. Least square interaction means of marbling degree by temperature on Warner-Bratzler shear force (WBSF) of *longissimus* muscle.

Source of Variation	WBSF (kg)	Standard Error
Marbling Degree* Temperature (ºC)		
Select * 40	2.94	0.16
Choice * 40	3.06	0.16
Select * 45	3.22	0.16
Choice * 45	2.78	0.16
Select * 50	3.01	0.16
Choice * 50	2.46	0.16
Select * 55	2.54	0.17
Choice * 55	2.41	0.16
Select * 60	2.92	0.17
Choice * 60	2.5	0.16
Select * 65	3.19	0.16
Choice * 65	2.71	0.16
Select * 70	3.47	0.16
Choice * 70	3.16	0.16
Select * 75	3.94	0.16
Choice * 75	3.37	0.16
Select * 80	4.05	0.16
Choice * 80	3.02	0.16
P-value	0.03	
LSD	≈0.45	