EFFECTS OF COOKING METHOD, INTERNAL TEMPERATURE AND QUALITY GRADE ON TENDERNESS AND COOKING TRAITS OF HOLSTEIN BEEF STRIP STEAKS

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Story In Brief

Fifteen Holstein steer carcasses from each of four quality levels (U.S. low Select, high Select, low Choice, average Choice) were selected randomly and strip loins were removed to evaluate the effects of cooking method and endpoint internal temperature on tenderness and cooking traits of beef strip steaks. Steaks were removed, assigned to one of three cooking methods (clam-shell, impingement oven or Farberware broiler) and cooked to one of three degrees of doneness (140^{o}F = medium rare, 158^{o}F = medium or 176^{o}F = medium well). Quality level (marbling score) appeared to serve as an “insulator” in that steaks with more marbling could be cooked to an increased degree of doneness while maintaining acceptable tenderness values. Steaks cooked to a medium rare degree of doneness resulted in more desirable shear force values, shorter cooking times and lower cooking losses than steaks cooked medium or medium well. Shear force was also affected by the method of cookery; steaks cooked on the Farberware produced the most desirable (lowest) shear force values while impingement oven-cooked steaks had the highest. Farberware cooking also resulted in the highest cooking losses and cooking times; clam-shell cookery resulted in the lowest cooking losses and required the shortest time to cook. These data indicate meat tenderness is affected by quality grade, cookery method and degree of doneness.

(Key Words: Tenderness, Temperature, Cooking Method.)

Introduction

Beef tenderness is an important characteristic of U.S. beef, especially in the export market (U.S. Meat Export Federation, 1994), but in the effort to reduce excess fat, concern pertaining to tenderness or the inadequacy thereof has increased (NCA, 1996). Currently, beef eating satisfaction is predicted by quality grades (USDA, 1989) and beef packers receive a premium for beef with increased marbling scores as a result of signals received from purveyors and retailers. However, work reported by Draudt (1972) and Parrish et al. (1973) indicated that final internal temperature had a greater effect on palatability than

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marbling. Smith et al. (1984) found limited but significant improvements in palatability associated with marbling and Smith and Carpenter (1974) stated that steaks with higher degrees of marbling provide “insurance” in maintaining tenderness when high-temperature cookery is employed and meat is cooked until it is well-done. Additional work by Savell et al. (1987, 1989) indicated consumers associate higher palatability with increased marbling. Studies by Cross et al. (1976) as well as the National Live Stock and Meat Board (1995) concluded degree of doneness affects beef palatability, while Berry and Leddy (1989) and the National Live Stock and Meat Board (1995) determined that tenderness was affected by method of cookery. Accordingly, this study was conducted to determine the effects of cooking method, internal temperature and quality grade on tenderness and cooking traits of beef strip steaks.

Materials and Methods

Selection of Loins and Processing of Steaks. Fifteen Holstein carcasses from steers 9 to 30 months of age ("A" maturity) weighing 700 to 850 pounds and having an external fat thickness of 0.20 to 0.35 inch, a 11.0 to 14.0 square inch ribeye area and one of four marbling scores (Sl^{10-40}, Sl^{60-90}, Sm^{10-80}, Mt^{10-90}) were selected randomly at 48 hours postmortem in a commercial meat processing facility. Strip loins (180A) from the left side of each carcass were removed, vacuum packaged and transported to the Oklahoma State University Meats Laboratory where they were aged for 14 days at 36^{o}F. Eight steaks (1.0 inch thick) were cut, subsequently frozen (-22^{o}F) and were assigned to one of three internal temperature endpoints (140, 158 or 176^{o}F) using one of three cooking methods (clam-shell cooker, impingement oven or Farberware broiler), with the exception that no steaks were assigned to an internal temperature of 140^{o}F on the Farberware broilers.

Cooking Procedures. Steaks were thawed at 36^{o}F for a period of 24 hours. Three cooking procedures were used. The first method involved clam-shell cooking to internal temperatures of 140, 158 or 176^{o}F. This procedure has been used exclusively by the McDonald’s Corporation to rapidly achieve a final internal temperature. The second method of cookery was the impingement oven, frequently used by the pizza industry, in which steaks were cooked to internal temperatures of 140, 158 or 176^{o}F. The third method involved electric broiling (Farberware Open-Hearth), a procedure that has been used extensively in many research studies, to achieve final internal temperatures of 158 or 176^{o}F.

Tenderness and Cooking Characteristics. Once steaks reached the desired internal temperature endpoint, they were cooled to room temperature for a minimum of two hours at which time an average of six 0.5 inch diameter cores were removed for shear force (tenderness) measurement using a Warner-Bratzler attachment to an Instron Universal Testing Machine. Cooking characteristics included 1) time and 2) cook loss. Time, expressed on an absolute basis in minutes or in minutes per 3 ounces of cooked steak, was defined to be the duration of the cooking process from initial steak placement to attainment of the desired internal temperature. Steaks were weighed prior to and two hours post-cooking to determine cook loss expressed as a percentage of raw steak weight.

Statistical Analyses. Data were first analyzed to determine differences in cooking steaks to one of three internal temperatures using the clam-shell cooker or the impingement oven. Data were then analyzed to determine differences in shear force and cooking traits using three methods and two internal temperatures. The statistical model included quality grade as the whole plot and steak nested within quality grade as the appropriate error term. The split-plot consisted of method of cookery, internal temperature endpoint and all appropriate two and three-way interactions. Least squares means were partitioned to assess main effects and interactions upon obtaining a significant F-test. Levene's test for homogeneity of variance was used to assess differences in shear force variances. Significance was reported at the $P<.05$ level.

Results and Discussion

Due to the design of the study, marbling scores differed for all quality levels. No differences in carcass weight, maturity, adjusted fat thickness or ribeye area were detected for carcasses when stratifed by quality level (Table 1).

Comparison of Three Internal Temperatures. The effect of quality grade on tenderness and cooking traits of strip steaks cooked to 140, 158 or 176°F is summarized in Table 2. No differences in cooking time (minutes or minutes per 3 ounces of cooked product) or cooking loss were found among quality grades; however, shear force values became more ($P<.05$) desirable (decreased) as quality level increased from low Select to average Choice. Additionally, steaks with at least "high slight" marbling scores were less variable in shear force than steaks with "low slight" marbling scores.

Endpoint internal temperature effects on cooking time and loss, shear force and shear force variance are reported in Table 3. Steaks cooked to 140°F required ($P<.05$) shorter cooking times, had lower cook losses and more desirable shear force values than steaks cooked to 158 or 176°F. Cooking steaks to internal temperatures of 158°F resulted in intermediate cooking times and losses, while steaks cooked to 176°F required the longest time to cook and had the highest cooking loss values. No difference in shear force was observed among steaks cooked to 158 or 176°F, but steaks cooked to 176°F were the most variable ($P<.05$) in shear force.

Table 4 contains the effect of cooking method on tenderness and cooking traits of Holstein strip steaks. Cooking time, cooking loss and shear force were more ($P<.05$) desirable (shorter and lower) for steaks cooked on the clam-shell cooker than those cooked on the impingement oven.

Shear force was also affected by the quality grade x internal temperature, quality grade x method of cookery and the internal temperature x method of cookery interactions. The quality grade x internal temperature interaction is depicted in Figure 1. When cooked to 140°F, steaks of low Select quality required more ($P<.05$) shear force than low Choice or average Choice steaks, while at 158°F low Select steaks were the toughest ($P<.05$) and steaks with modest marbling (average Choice) were the most ($P<.05$) tender. However, at 176°F no differences ($P>.05$) in shear force were observed for steaks of high Select, low Choice or average Choice quality, but steaks of low Select quality had the highest ($P<.05$) shear force values.

The quality grade by cooking method effect on shear force of strip steaks revealed that cooking steaks on the clam-shell cooker resulted in lower ($P<.05$) shear force values for low Select and low Choice steaks; however, no differences ($P>.05$) in shear force were found between steaks of high Select or average Choice quality grades. The internal temperature endpoint x method of cookery interaction significantly influenced time required to cook steaks as well as shear force values. Time was different for all internal temperatures when stratified by cooking method except steaks cooked to 158 and 176°F on the impingement oven did not differ.

The internal temperature by method of cookery effect on shear force of strip steaks is shown in Figure 2. At 140 and 176°F, steaks cooked on the clam-shell cooker had more desirable shear force values than steaks cooked on the impingement oven, but no differences ($P>.05$) in shear force due to cooking method were observed at 158°F. Interestingly, when steaks were cooked to 176°F on the clam-shell they were not only more tender than steaks cooked on the impingement oven, but they were also more tender than steaks cooked on the clam-shell to 158°F. This decrease in shear force may partially be due to the increased collagen solubility when cooking to higher degrees of doneness.

Comparison of Three Cooking Methods. The effect of quality grade on tenderness and cooking traits of strip steaks cooked to 158 or 176°F (not shown in tabular form) revealed quality grade did not affect cooking time or shear force, although shear force tended to increase as marbling score decreased. Steaks of average Choice quality had lower cooking losses than high Select steaks, while cook loss did not differ among quality levels for steaks of low Select or low Choice quality.

Internal temperature effects on cooking time, cook loss, shear force and shear force variance revealed cooking steaks to higher internal temperatures resulted in longer cooking times. Cooking losses and shear force values were more undesirable for steaks cooked to higher degrees of doneness.

Tenderness and cooking traits were significantly different for all methods used to cook Holstein strip steaks. Steaks cooked on the clam-shell had the shortest (P<.05) cooking times as well as the lowest (P<.05) cooking losses but were intermediate in shear force. Steaks cooked on the impingement oven produced steaks with the highest shear force values but were intermediate in cooking time and cooking loss. Farberware broiled steaks had the most (P<.05) desirable shear force values, required the longest time to reach the desired endpoint temperature and had the highest (P<.05) cooking loss values.

Shear force, cooking loss and cooking time for steaks cooked on the clam-shell cooker, impingement oven or Farberware broiler to 158 or 176°F were all significantly affected by the cooking method by internal temperature interaction. Shear force values were the highest (P<.05) for steaks cooked on the impingement oven to 176°F, while cooking steaks to 158°F on the Farberware resulted in the most desirable (P<.05) values. Clam-shell cooking to 176°F produced steaks that were more tender (P<.05) than all other cooking method by internal temperature combinations. Cooking loss was highest (P<.05) for all steaks cooked to 176°F with Farberware broiling resulting in the largest (P<.05) losses and clam-shell cooking the lowest (P<.05). When cooked to 158°F, clam-shell cookery resulted in the least (P<.05) cooking loss, while no difference (P>.05) was found between the impingement oven or the Farberware broiler. The method by temperature interaction revealed cooking time (total time and time per 3 ounce cooked portion) was shortest (P<.05) for clam-shell cooking, intermediate (P<.05) for the impingement oven and longest (P<.05) for Farberware broiling, while steaks cooked to 176°F required more time (P<.05) to reach the desired degree of doneness than steaks cooked to 158°F.

The quality grade by internal temperature interaction also significantly affected shear force. Steaks of low Select quality cooked to an internal temperature of 176°F were the toughest (P<.05), while low Select steaks cooked to 158°F steaks required more shear force (P<.05) than all other quality grade by internal temperature combinations. No differences (P>.05) in shear force were observed among average Choice, low Choice or high Select steaks cooked to 176°F. Average Choice steaks cooked to 158°F were more tender (P<.05) than all other steaks except average Choice steaks cooked to 176°F and low Choice steaks cooked to 158°F.

Implications

Results from this study indicate meat tenderness is influenced by a combination of factors. Steaks cooked to lower internal temperature endpoints result in decreased cooking times and cooking losses as well as lower shear force values. Quality level (marbling) appears to serve as an "insurance policy" allowing steaks with increased marbling scores (at least high Select quality) to be cooked to higher degrees of doneness without eroding palatability. Moreover, the method by which steaks are cooked is yet another factor contributing to acceptability of meat tenderness.

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Table 1. Carcass characteristics stratified by quality grade.

	Quality level			
Trait	Low Select	High Select	Low Choice	Average Choice
Carcass weight, lb	762.6	776.0	780.2	781.3
Maturity score[a]	A^{74}	A^{75}	A^{74}	A^{74}
Fat thickness, in	.28	.32	.29	.32
Ribeye area, in^2	11.8	11.7	11.9	11.9
Marbling score[b]	Sl^{28f}	Sl^{72e}	Sm^{41d}	Mt^{42c}

[a] Carcass maturity scores: A = approximately 9 to 30 months of chronological age at slaughter (USDA, 1989).

[b] Marbling score: Sl^{00-49}=low Select; Sl^{50-99}=high Select; Sm^{00-99}=low Choice; Mt^{00-99}=average Choice (USDA, 1989).

[c,d,e,f] Means in the same row with a common superscript letter do not differ (P>.05).

Table 2. Effect of quality grade on tenderness and cooking traits of Holstein strip steaks.

	Quality level			
Trait	Low Select	High Select	Low Choice	Average Choice
Cooking time				
minutes	9.7	9.8	9.8	9.8
minutes/3oz cooked	4.4	4.3	4.3	4.3
Cook loss, %	25.1	25.2	25.1	24.9
Shear force, lb	8.02[a]	7.32[b]	7.19[bc]	7.03[c]
Shear force variance, lb^2	.65[d]	.44[e]	.48[e]	.48[e]

[a,b,c] Means in the same row with a common superscript letter do not differ (P>.10).

[d,e] Means in the same row with a common superscript letter do not differ (P>.05).

Table 3. Effect of endpoint internal temperature on tenderness and cooking traits of Holstein strip steaks.

Trait	Endpoint internal temperature[a]		
	140°F	158°F	176°F
Cooking time			
minutes	9.0[d]	9.5[c]	10.8[b]
minutes/3oz cooked	3.9[d]	4.2[c]	4.8[b]
Cook loss, %	22.2[d]	24.1[c]	29.0[b]
Shear force, lb	6.66[c]	7.80[b]	7.72[b]
Shear force variance, lb^2	.89[c]	1.04[c]	1.30[b]

[a] Degree of doneness: 140°F = medium rare; 158°F = medium; 176°F = medium well.

[b,c,d] Means in the same row with a common superscript letter do not differ (P>.05).

Table 4. Effect of cooking method on tenderness and cooking traits of Holstein strip steaks.

Trait	Cooking method	
	Clam-shell	Impingement
Cooking time		
minutes	4.9[b]	14.6[a]
minutes/3oz cooked	2.3[b]	6.3[a]
Cook loss, %	23.9[b]	26.3[a]
Shear force, lb	7.16[b]	7.61[a]
Shear force variance, lb^2	1.12[a]	1.17[a]

[a,b] Means in the same row with a common superscript letter do not differ (P>.05).

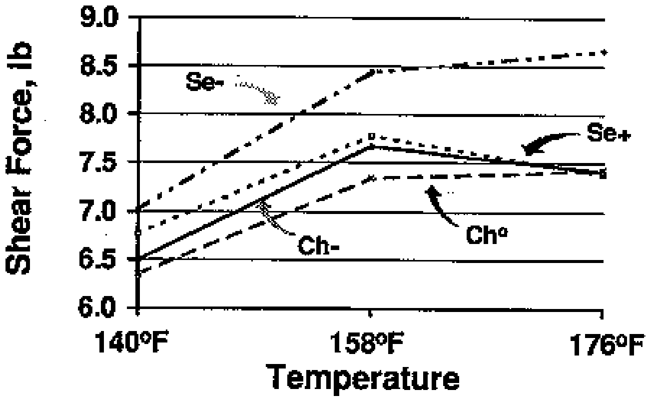

Figure 1. Quality grade by internal temperature endpoint effect on shear force of Holstein beef strip steaks.

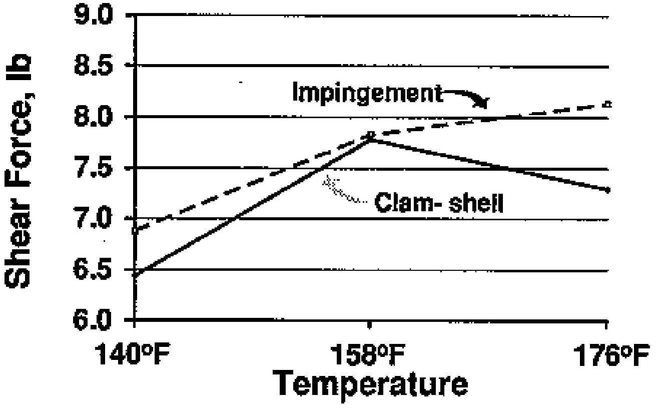

Figure 2. **Internal temperature endpoint by method of cookery effect on shear force of Holstein beef strip steaks.**