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IN-HOME CONSUMER EVALUATIONS OF INDIVIDUAL MUSCLES FROM BEEF ROUNDS SUBJECTED TO TENDERIZATION TREATMENTS

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Introduction

The U. S. beef industry is moving towards merchandising individual muscles, and has been focused on identifying and improving underutilized muscles from the round and chuck as a way to increase the value of the entire carcass. Kolle et al. (2004) investigated the effects of blade tenderization, enzymatic tenderization, and injection with salt and phosphate solutions on individual muscles from beef rounds. Kolle et al. (2004) found that responses to tenderization systems were largely muscle dependent, with the *M. semimembranosus*, *M. adductor*, *M. rectus femoris*, and *M. vastus lateralis* showing promising improvements in tenderness for all tenderization treatments. Although most research has suggested that tenderness is the most important determinant of beef palatability, a steak that is lacking in any palatability criteria is likely to disappoint consumers. In addition, consumer controlled factors such as degree of doneness and cooking method can have a great impact on consumer satisfaction (Lorenzen et al., 1999; Neely et al., 1999; Savell et al., 1999).

One of the limitations of objective measures of meat tenderness is that many factors that can influence tenderness and palatability, such as cooking method and degree of doneness, are controlled (Kolle et al., 2004). In-home consumer evaluation studies have given excellent insights into how consumers prepare different types of steaks, what degree of doneness they prefer, and how these factors impact their satisfaction with beef products. An in-home study by Neely et al. (1998) found low customer satisfaction ratings for top round steaks were observed primarily because consumers cooked with dry heat methods rather than moist heat.

Of the muscles that responded positively to the various tenderization methods in Kolle et al. (2004), it is unclear which factors augment the existing palatability characteristics of the steaks from individual round muscles in the most beneficial way. An in-home study was conducted to give insight into consumer's ability to pick up both positive and negative effects of tenderization treatments, and subsequent tenderization recommendations can be made to retailers and processors so that muscles from beef rounds are tenderized in a manner that maximizes palatability.

Objectives

To determine in-home consumer palatability responses for steaks from individual muscles from beef rounds that have been tenderized using blade tenderization or injection with a salt and phosphate solution, and determine which treatment works best with each muscle to optimize palatability.

Methodology

USDA Select, beef inside rounds (IMPS#169A) (n = 67) and knuckles (IMPS# 167A) (n = 66) were purchased from a local processing facility and shipped to the Rosenthal Meat Science and Technology Center at Texas A&M University. Subprimals were assigned randomly to one of three treatments (control, blade tenderization, or injection with salt and phosphate solution). Inside rounds were separated into *M. semimembranosus* and *M. adductor*, and knuckles were separated into *M. rectus femoris* and *M. vastus lateralis*. Muscles were trimmed, defatted, and treated according to the treatment group they were assigned. Final pH for post-processing control muscles were 5.75 ± 0.12, 5.75 ± 0.11, 5.74 ± 0.08, and 5.75 ± 0.08 for the *M. semimembranosus*, *M. adductor*, *M. rectus femoris*, and *M. vastus lateralis*, respectively. The blade tenderization treatment consisted of a double pass through a 286 blade (13 rows of 22 blades) TEND-R-RITE Blade tenderizer (TR-2, Bettcher Industries, Inc., Birmingham, OH). Final pH for post-processing blade tenderized muscles were 5.70 ± 0.13, 5.69 ± 0.09, 5.48 ± 0.69, and 5.51 ± 0.05 for the *M. semimembranosus*, *M. adductor*, *M. rectus femoris*, and *M. vastus lateralis*, respectively. The injection/enhancement treatment consisted of a water solution containing 5.0% sodium chloride and 2.95% sodium tripolyphosphate (Brifisol ® 512, BK Giulini Corp., Simi Valley, CA). The solution (pH 7.61 ± 0.23 at 16.1° ± 1.07°C) was injected into the muscles at a 15% level using a single pass through a commercial injection machine (Inject Star BI 72, Inject Star, Inc., Brookfield, CT). Final concentrations of sodium chloride and sodium tripolyphosphate in the muscles were estimated to be 0.71% and 0.42%, respectively. Final post processing pH for injected muscles were 5.96 ± 0.13, 5.92 ± 0.21, 5.78 ± 0.14, and 5.89 ± 0.17 for the *M. semimembranosus*, *M. adductor*, *M. rectus femoris*, and *M. vastus lateralis*, respectively. After processing, muscles were cut into 2.54 cm steaks, individually vacuum-packaged, and frozen. Three steaks were cut from each muscle perpendicular to the muscle fiber orientation starting from the most cranial aspect of each muscle and moving towards the most caudal aspect (or proximal and distal when appropriate).

Steaks from each treatment group (control, blade tenderized, and injected) within a muscle from both muscles within a subprimal were assigned randomly to a box so that each box had six steaks (two muscles * three treatments). Each box also contained a survey with directions, a cooked beef color guide, a food safety guide, and a stamped, addressed envelope. Boxes were stored a -10º C until delivery to consumers.

Beef consumers (n=395) were solicited through direct contact by Texas A&M University personnel (261 consumers completed the study). Participants were given a box of steaks and asked to prepare those steaks as they normally would if they had purchased them from the supermarket. Consumers were directed to cook only one steak per meal, per consumer, and it was suggested that they cook two steaks per week for a total of three

weeks for timeliness purposes. Preparers were asked to identify the cooking method (outdoor or indoor grill, pan-broil, pan-fry, stir-fry, broil, oven roasted, uncovered, braise and simmer, or stew) used by referring to the definitions provided in the included directions. The approximate degree of doneness was determined by consumers using the National Cattlemen's Beef Association beef steak color guide provided for them in the box. The consumers were asked to evaluate steaks for overall-like, tenderness, juiciness, flavor intensity, and flavor desirability using a 10-point scale (10 = extreme like, extremely tender, extremely juicy, extremely intense, and extremely desirable; 1=extreme dislike, extremely tough, extremely dry, extremely bland, and extremely undesirable). This study was approved by the Institutional Review Board at Texas A&M University, and informed consent was obtained from all participants.

Data were analyzed for each muscle individually using the PROC GLM procedures of SAS (SAS Institute, Cary, NC). Initial models tested the main effects of tenderization treatment and cooking method and their interaction. Cooking methods were pooled into four categories including: grill (outdoor and indoor grilling), oven (broil and oven roasted, uncovered), skillet (pan-broil, pan-fry, and stir-fry), and moist cookery (braise and simmer and stew). Within cooking methods displaying sufficient numbers of steaks cooked to various degrees of doneness (grilling and skillet methods), the effects of degree of doneness and tenderization treatment were tested. If there was no interaction, only the degree of doneness means were presented as other means were presented in the previous analysis. A predetermined α of 0.05 was used for all determinations of statistical significance.

Results & Discussion

Tenderization Treatments

Least-squares means for consumer evaluations of steaks are reported in Table 1. *M. semimembranosus* steaks from the salt/phosphate treatment received the highest ($P < 0.05$) ratings for all traits compared to those from the control and blade tenderized treatments. For the *M. rectus femoris*, consumers gave steaks from the salt/phosphate treatment higher ($P < 0.05$) palatability ratings compared to the control steaks, and higher ($P < 0.05$) tenderness and juiciness ratings than steaks from the blade tenderized treatment. For the *M. vastus lateralis* steaks, those that were from the salt/phosphate treatment received higher ($P < 0.05$) palatability ratings for all traits compared to the steaks from the blade tenderization treatment and the controls. In general, the salt/phosphate treatment resulted in improved palatability compared to the blade tenderized treatment and to the controls. In most cases, blade tenderizing did not improve palatability compared to controls.

Table 1
Least-squares means (SEM) for consumer evaluations of beef steaks treated with blade tenderization or salt/phosphate injection

			Treatment		
Muscle	**Attribute**	**Control**	**Blade**	**Inject**	***P* > F**
M. adductor	Tenderness	5.7 ± 0.2	6.2 ± 0.2	6.3 ± 0.2	0.06
	Juiciness	5.4 ± 0.2	5.7 ± 0.2	6.0 ± 0.2	0.13
	Flavor Intensity	5.9 ± 0.2	6.2 ± 0.2	6.3 ± 0.2	0.15
	Flavor Desirability	6.0 ± 0.2	6.3 ± 0.2	6.3 ± 0.2	0.35
	Overall Like	6.3 ± 0.2	6.8 ± 0.2	6.8 ± 0.2	0.10
M. semimembranosus	Tenderness	6.0 ± 0.2b	6.1 ± 0.2b	6.6 ± 0.2a	0.04
	Juiciness	5.5 ± 0.2b	5.3 ± 0.2b	6.2 ± 0.2a	<0.01
	Flavor Intensity	5.9 ± 0.2b	6.0 ± 0.2b	6.5 ± 0.2a	0.05
	Flavor Desirability	6.0 ± 0.2b	6.0 ± 0.2b	6.7 ± 0.2a	0.01
	Overall Like	6.4 ± 0.2b	6.5 ± 0.2b	7.1 ± 0.2a	0.02
M. rectus femoris	Tenderness	6.3 ± 0.2b	6.7 ± 0.2b	7.2 ± 0.2a	<0.01
	Juiciness	5.9 ± 0.2b	6.1 ± 0.2b	6.9 ± 0.2a	<0.01
	Flavor Intensity	6.3 ± 0.2b	6.5 ± 0.2ab	7.0 ± 0.2a	0.02
	Flavor Desirability	6.2 ± 0.2b	6.5 ± 0.2ab	6.9 ± 0.2a	0.02
	Overall Like	6.5 ± 0.2b	6.9 ± 0.2ab	7.3 ± 0.2a	<0.01
M. vastus lateralis	Tenderness	5.4 ± 0.2b	5.7 ± 0.2b	6.5 ± 0.2a	<0.01
	Juiciness	5.3 ± 0.2b	5.6 ± 0.2b	6.2 ± 0.2a	0.01
	Flavor Intensity	5.5 ± 0.2b	5.8 ± 0.2b	6.6 ± 0.2a	<0.01
	Flavor Desirability	5.6 ± 0.2b	6.0 ± 0.2b	6.7 ± 0.2a	<0.01
	Overall Like	5.8 ± 0.2b	6.1 ± 0.2b	6.9 ± 0.2a	<0.01

Means within the same row lacking common letters (a,b) differ ($P < 0.05$).

Cooking methods

When looking at the various cooking methods (Table 2), *M. adductor* steaks cooked in the skillet and using a grilling method received higher ($P < 0.05$) consumer ratings for juiciness than steaks cooked in an oven or using moist cookery. For flavor intensity and desirability, steaks cooked in a skillet, on the grill, and in the oven were ranked higher ($P < 0.05$) than those cooked using moist cookery. This might suggest that cooking with moist heat cookery may reduce the flavor attributes of the *M. adductor* steak to an unacceptable level for consumers. For *M. rectus femoris* steaks, tenderness ratings were higher ($P < 0.05$) for those steaks cooked using moist cookery and in a skillet than those cooked in an oven or on a grill. For *M. vastus lateralis*, the steaks cooked with moist cookery were given higher ratings ($P < 0.05$) for tenderness, whereas, those cooked on a skillet, in the oven, or on a grill, were given similar and lower ratings. The increase in tenderness of the *M. vastus lateralis* steaks cooked using moist heat also created higher ($P < 0.05$) ratings for overall like suggesting that the role that moist heat cookery played in increasing tenderness, increased the overall palatability of the steak for consumers.

In general, cooking methods did not provide substantial increases in consumer palatability attributes. For the knuckle steaks (*M. rectus femoris and M. vastus lateralis*),

moist-heat cookery did create an increase in tenderness ratings from consumers over the dry-heat methods (grill and oven).

Table 2
Least-squares means (SEM) for consumer evaluations of beef steaks cooked with grilling, oven moist, cookery methods, or in a skillet

		Cooking Method				
Muscle	**Attribute**	**Grill**	**Oven**	**Moist**	**Skillet**	***P* > F**
M. adductor	Tenderness	6.1 ± 0.2	6.1 ± 0.3	5.7 ± 0.4	6.5 ± 0.2	0.17
	Juiciness	6.0 ± 0.2ab	5.4 ± 0.3b	5.3 ± 0.4b	6.2 ± 0.2a	0.05
	Flavor Intensity	6.4 ± 0.1a	6.2 ± 0.3ab	5.4 ± 0.4b	6.6 ± 0.2a	0.02
	Flavor Desirability	6.3 ± 0.1a	6.4 ± 0.3a	5.4 ± 0.4b	6.7 ± 0.2a	0.02
	Overall Like	6.4 ± 0.1	6.8 ± 0.3	6.4 ± 0.4	6.9 ± 0.2	0.21
M. semimembranosus	Tenderness	5.9 ± 0.1	6.3 ± 0.4	6.6 ± 0.4	6.0 ± 0.2	0.33
	Juiciness	5.8 ± 0.2	5.4 ± 0.4	5.8 ± 0.4	5.6 ± 0.2	0.72
	Flavor Intensity	6.1 ± 0.1	6.1 ± 0.3	6.4 ± 0.4	6.1 ± 0.2	0.90
	Flavor Desirability	6.1 ± 0.1	6.2 ± 0.4	6.4 ± 0.4	6.2 ± 0.2	0.91
	Overall Like	6.5 ± 0.2	6.8 ± 0.3	7.0 ± 0.3	6.4 ± 0.2	0.38
M. rectus femoris	Tenderness	6.4 ± 0.2b	6.3 ± 0.4b	7.2 ± 0.3a	6.9 ± 0.2a	0.03
	Juiciness	6.3 ± 0.2	5.9 ± 0.4	6.6 ± 0.3	6.6 ± 0.2	0.26
	Flavor Intensity	6.4 ± 0.2	6.3 ± 0.4	6.8 ± 0.3	6.9 ± 0.2	0.29
	Flavor Desirability	6.4 ± 0.2	6.2 ± 0.4	6.7 ± 0.3	6.8 ± 0.2	0.21
	Overall Like	6.7 ± 0.1	6.6 ± 0.3	7.2 ± 0.3	7.1 ± 0.2	0.21
M. vastus lateralis	Tenderness	5.6 ± 0.2b	5.1 ± 0.3b	7.1 ± 0.3a	5.6 ± 0.2b	<0.01
	Juiciness	5.7 ± 0.2	5.3 ± 0.4	6.1 ± 0.3	5.7 ± 0.2	0.40
	Flavor Intensity	6.1 ± 0.2	5.4 ± 0.3	6.2 ± 0.3	6.1 ± 0.2	0.26
	Flavor Desirability	5.9 ± 0.2	5.7 ± 0.3	6.6 ± 0.3	6.2 ± 0.2	0.21
	Overall Like	6.1 ± 0.2b	5.7 ± 0.3b	7.1 ± 0.3a	6.1 ± 0.2b	0.01

Means within the same row lacking common letters (a,b) differ ($P < 0.05$).

Degree of Doneness

M. semimembranosus steaks cooked on a grill (Table 3) to medium rare and below received the highest ($P < 0.05$) ratings for juiciness, flavor intensity, and desirability. The method of cookery clearly influenced consumer palatability ratings for *M. rectus femoris* steaks cooked on a grill. Lower degrees of doneness (medium rare and below and medium) received higher ($P < 0.05$) tenderness ratings than steaks cooked to well done. Juiciness ratings increased as the degree of doneness decreased, with steaks cooked to medium rare or below receiving higher ($P < 0.05$) ratings than those cooked to medium well. In addition, those steaks cooked to medium well produced higher ($P < 0.05$) juiciness ratings than those cooked to well done. Steaks cooked at medium rare and below received the highest ($P < 0.05$) ratings for flavor intensity. Flavor desirability and overall like ratings received similar ratings as those steaks cooked to medium rare and below. In general, lower degrees of doneness produced higher palatability ratings. This, combined with other findings, suggest that a dry heat cookery method like grilling may be acceptable for the *M. rectus femoris* if cooked to lower degrees of doneness.

Table 3
Least-squares means (SEM) for consumer evaluations of beef steaks cooked on a grill.

Muscle	Attribute	Degree of Doneness				P > F
		Med Rare and Rare	Medium	Medium Well	Well Done	
M. adductor	Tenderness	5.8 ± 0.4	5.7 ± 0.3	6.4 ± 0.3	6.4 ± 0.3	0.22
	Juiciness	5.9 ± 0.4	5.7 ± 0.3	6.2 ± 0.3	6.1 ± 0.4	0.67
	Flavor Intensity	6.5 ± 0.4	6.2 ± 0.2	6.7 ± 0.2	6.3 ± 0.3	0.36
	Flavor Desirability	6.4 ± 0.4	6.0 ± 0.3	6.6 ± 0.3	6.1 ± 0.3	0.36
	Overall Like	6.1 ± 0.4	6.1 ± 0.2	6.7 ± 0.2	6.8 ± 0.3	0.22
M. semimembranosus	Tenderness	6.8 ± 0.4	5.8 ± 0.2	5.6 ± 0.3	6.0 ± 0.3	0.09
	Juiciness	7.0 ± 0.4a	5.9 ± 0.3	5.7 ± 0.3B	5.1 ± 0.4b	<0.01
	Flavor Intensity	7.3 ± 0.4a	6.0 ± 0.2b	5.7 ±0.2b	5.8 ± 0.3b	<0.01
	Flavor Desirability	7.4 ± 0.4a	6.0 ± 0.2b	5.8 ± 0.3b	5.9 ± 0.3b	0.01
	Overall Like	7.1 ± 0.4	6.4 ± 0.2	6.4 ± 0.2	6.4 ± 0.3	0.38
M. rectus femoris	Tenderness	6.9 ± 0.3a	6.6 ± 0.3a	6.2 ± 0.3ab	5.5 ± 0.4b	0.04
	Juiciness	7.2 ± 0.3a	6.5 ± 0.3ab	6.0 ± 0.3b	4.3 ± 0.4c	<0.01
	Flavor Intensity	7.4 ± 0.3a	6.4 ± 0.3b	6.0 ± 0.3b	5.7 ± 0.4b	<0.01
	Flavor Desirability	7.2 ± 0.3a	6.5 ± 0.3ab	5.9 ± 0.3b	5.4 ± 0.4b	0.01
	Overall Like	7.2 ± 0.3a	6.9 ± 0.2ab	6.3 ± 0.3b	6.1 ± 0.4b	0.05
M. vastus lateralis	Tenderness	5.5 ± 0.3	5.8 ± 0.3	5.1 ± 0.3	6.7 ± 0.5	0.07
	Juiciness	6.1 ± 0.4	5.9 ± 0.3	5.2 ± 0.3	5.2 ± 0.5	0.18
	Flavor Intensity	6.1 ± 0.3	6.1 ± 0.3	5.7 ± 0.3	7.0 ± 0.5	0.22
	Flavor Desirability	5.9 ± 0.4	6.1 ± 0.3	5.4 ± 0.3	7.0 ± 0.5	0.10
	Overall Like	6.1 ± 0.3	6.2 ± 0.3	5.6 ± 0.3	6.9 ± 0.5	0.20

Means within the same row lacking common letters (a-c) differ ($P < 0.05$).

In Table 4, least squares means for consumer evaluations of steaks cooked using moist cookery are presented. For the attribute of overall like, consumers rated those *M. semimembranosus* steaks cooked medium rare and below the lowest ($P < 0.05$).

Table 4
Least-squares means (SEM) for consumer evaluations of beef steaks cooked using moist cookery.

Muscle	Attribute	Degree of Doneness				P > F
		Med Rare and Rare	Medium	Medium Well	Well Done	
M. adductor	Tenderness	-	4.7 ± 1.2	4.9 ± 0.8	6.1 ± 0.5	0.32
	Juiciness	-	4.7 ± 1.1	4.9 ± 0.7	5.4 ± 0.5	0.76
	Flavor Intensity	-	5.0 ± 1.0	5.4 ± 0.7	5.3 ± 0.4	0.95
	Flavor Desirability	-	5.0 ± 1.1	4.3 ± 0.8	5.8 ± 0.5	0.24
	Overall Like	-	5.3 ± 1.0	6.7 ± 0.6	6.4 ± 0.4	0.52
M. semimembranosus	Tenderness	1.1 ± 2.0	7.8 ± 1.2	6.3 ± 0.9	6.8 ± 0.4	0.06
	Juiciness	2.5 ± 2.4	7.3 ± 1.4	5.6 ± 1.1	5.8 ± 0.5	0.41
	Flavor Intensity	3.1 ± 2.1	6.5 ± 1.2	5.7 ± 1.0	6.6 ± 0.4	0.34
	Flavor Desirability	2.0 ± 2.0	6.7 ± 1.2	6.0 ± 1.0	6.7 ± 0.4	0.17
	Overall Like	2.0 ± 2.0b	8.7 ± 1.2a	6.1 ± 0.9a	7.1 ± 0.4a	0.05
M. rectus femoris	Tenderness	7.0 ± 2.1	6.9 ± 1.0	7.3 ± 0.5	7.4 ± 0.4	0.98
	Juiciness	5.1 ± 2.4	5.4 ± 1.1	6.8 ± 0.6	6.9 ± 0.5	0.54
	Flavor Intensity	4.5 ± 2.4	5.5 ± 1.1	7.6 ± 0.6	6.8 ± 0.4	0.29
	Flavor Desirability	3.7 ± 2.3	5.2 ± 1.1	7.5 ± 0.6	6.9 ± 0.4	0.17
	Overall Like	5.9 ± 2.0	6.1 ± 0.9	7.1 ± 0.5	7.7 ± 0.4	0.33
M. vastus lateralis	Tenderness	7.8 ± 1.6	6.2 ± 0.8	6.9 ± 0.6	7.4 ± 0.5	0.63
	Juiciness	8.4 ± 1.7	5.2 ± 0.9	6.3 ± 0.6	5.8 ± 0.5	0.39
	Flavor Intensity	8.4 ± 1.3	4.7 ± 0.7	6.6 ± 0.5	6.1 ± 0.4	0.06
	Flavor Desirability	8.3 ± 1.5	4.9 ± 0.8	6.8 ± 0.5	6.7 ± 0.5	0.15
	Overall Like	8.3 ± 1.4	6.4 ± 0.7	7.2 ± 0.5	7.1 ± 0.4	0.57

Means within the same row lacking common letters (a,b) differ (P < 0.05).

Consumers who prepared *M. semimembranosus* steaks in an oven (Table 5) ranked steaks cooked to medium rare and below higher ($P < 0.05$) than those cooked to medium well and well done for overall like. For M. *rectus femoris* steaks cooked in an oven to medium rare and below, higher ratings ($P < 0.05$) were given for juiciness than for all other attributes. For *M. vastus lateralis* steaks cooked in an oven, ratings for juiciness and overall like were higher ($P < 0.05$) for steaks cooked to medium rare and below than those cooked to medium well and lowest ($P < 0.05$) for those cooked well done. For flavor intensity, those cooked to medium rare and below and medium were rated higher ($P < 0.05$) than those cooked well done. Ratings for overall like patterned those for juiciness signifying that juiciness plays an important role in the overall palatability of a round steak when cooked using a dry heat method.

Table 5

Least-squares means (SEM) for consumer evaluations of beef steaks cooked in an oven.

Muscle	Attribute	Degree of Doneness				P > F
		Med Rare and Rare	Medium	Medium Well	Well Done	
M. adductor	Tenderness	5.3 ± 1.1	6.4 ± 0.7	5.9 ± 0.7	6.3 ± 0.6	0.79
	Juiciness	6.0 ± 1.3	6.1 ± 0.8	5.7 ± 0.8	4.4 ± 0.7	0.36
	Flavor Intensity	6.0 ± 1.2	6.5 ± 0.7	6.8 ± 0.8	5.5 ± 0.6	0.57
	Flavor Desirability	6.6 ± 1.2	6.8 ± 0.7	6.7 ± 0.8	6.0 ± 0.6	0.83
	Overall Like	6.5 ± 1.0	7.0 ± 0.6	6.6 ± 0.7	7.1 ± 0.5	0.92
M. semimembranosus	Tenderness	5.2 ± 0.9	7.0 ± 0.8	5.4 ± 1.0	6.5 ± 0.6	0.37
	Juiciness	5.2 ± 1.0	6.8 ± 0.8	4.4 ± 1.1	5.1± 0.7	0.31
	Flavor Intensity	5.6 ± 1.0	7.2 ± 0.8	5.0 ± 1.0	6.1 ± 0.6	0.35
	Flavor Desirability	5.1 ± 0.9	7.0 ± 0.8	5.2 ± 1.0	6.5 ± 0.6	0.31
	Overall Like	5.8 ± 0.6a	6.9 ± 0.6ab	5.6 ± 0.7b	7.7 ± 0.4b	0.04
M. rectus femoris	Tenderness	7.4 ± 0.8	6.7 ± 0.5	6.3 ± 0.5	5.4 ± 0.6	0.21
	Juiciness	7.9 ± 0.7a	6.1 ± 0.4b	5.3 ± 0.5b	5.2 ± 0.5b	0.03
	Flavor Intensity	7.4 ± 0.8	6.7 ± 0.5	5.9 ± 0.5	5.9 ± 0.6	0.32
	Flavor Desirability	7.6 ± 0.8	6.4 ± 0.5	6.0 ± 0.5	5.3 ± 0.6	0.13
	Overall Like	8.2 ± 0.8	6.6 ± 0.4	6.4 ± 0.5	6.0 ± 0.6	0.17
M. vastus lateralis	Tenderness	6.1 ± 0.6	5.6 ± 0.5	4.6 ± 0.5	3.8 ± 0.7	0.06
	Juiciness	6.7 ± 0.5a	5.6 ± 0.5ab	5.1 ± 0.5b	3.3 ± 0.6c	<0.01
	Flavor Intensity	6.3 ± 0.6a	6.1 ± 0.5a	5.0 ± 0.5ab	4.0 ± 0.6b	0.02
	Flavor Desirability	7.2 ± 0.6a	6.2 ± 0.5ab	5.0 ± 0.5b	4.4 ± 0.6b	0.01
	Overall Like	6.7 ± 0.6a	6.1 ± 0.5ab	5.1 ± 0.5b	4.1 ± 0.6c	0.02

Means within the same row lacking common letters (a-c) differ ($P < 0.05$).

M. adductor steaks cooked in a skillet (Table 6) to a well done degree of doneness received lower ($P < 0.05$) ratings for juiciness than those cooked to medium rare and below and those cooked to medium well. For *M. vastus lateralis* steaks cooked in a skillet, juiciness ratings were higher ($P < 0.05$) for those steaks cooked to medium rare and below than for those cooked to medium well and well done.

Table 6
Least-squares means (SEM) for consumer evaluations of beef steaks cooked in a skillet.

Muscle	Attribute	Degree of Doneness				P > F
		Med Rare and Rare	Medium	Medium Well	Well Done	
M. adductor	Tenderness	6.8 ± 0.6	6.7 ± 0.3	6.8 ± 0.3	6.1 ± 0.3	0.47
	Juiciness	7.3 ± 0.6a	6.3 ± 0.3ab	6.6 ± 0.3a	5.6 ± 0.3b	0.03
	Flavor Intensity	7.3 ± 0.6	6.6 ± 0.4	7.0 ± 0.4	6.1 ± 0.3	0.19
	Flavor Desirability	7.3 ± 0.6	6.5 ± 0.3	7.1 ± 0.3	6.4 ± 0.3	0.43
	Overall Like	7.5 ± 0.6	6.9 ± 0.3	7.3 ± 0.3	6.5 ± 0.3	0.29
M. semimembranosus	Tenderness	5.2 ± 0.5	6.0 ± 0.4	6.5 ± 0.4	5.9 ± 0.4	0.32
	Juiciness	5.6 ± 0.5	5.9 ± 0.4	5.7 ± 0.4	5.4 ± 0.4	0.74
	Flavor Intensity	6.3 ± 0.5	6.2 ± 0.3	6.2 ± 0.4	5.9 ± 0.4	0.94
	Flavor Desirability	5.9 ± 0.5	6.2 ± 0.4	6.1 ± 0.4	6.3 ± 0.4	0.94
	Overall Like	5.4 ± 0.5	6.3 ± 0.4	6.8 ± 0.4	6.5 ± 0.4	0.24
M. rectus femoris	Tenderness	6.7 ± 0.5	7.3 ± 0.3	6.7 ± 0.3	6.9 ± 0.4	0.57
	Juiciness	7.5 ± 0.5	6.6 ± 0.3	6.4 ± 0.3	6.0 ± 0.4	0.11
	Flavor Intensity	7.5 ± 0.5	6.8 ± 0.3	6.9 ± 0.3	6.5 ± 0.4	0.53
	Flavor Desirability	7.1 ± 0.5	6.9 ± 0.4	6.7 ± 0.3	6.7 ± 0.4	0.91
	Overall Like	7.6 ± 0.5	7.1 ± 0.3	6.8 ± 0.3	7.0 ± 0.4	0.52
M. vastus lateralis	Tenderness	5.9 ± 0.5	5.7 ± 0.4	5.7 ± 0.3	4.8 ± 0.4	0.24
	Juiciness	6.7 ± 0.5a	5.9 ± 0.4ab	5.4 ± 0.4b	4.9 ± 0.4b	0.04
	Flavor Intensity	6.8 ± 0.4	6.1 ± 0.4	6.3 ± 0.3	5.4 ± 0.4	0.10
	Flavor Desirability	6.7 ± 0.5	6.1 ± 0.4	6.3 ± 0.4	5.7 ± 0.4	0.46
	Overall Like	6.5 ± 0.5	6.1 ± 0.4	6.4 ± 0.4	5.4 ± 0.4	0.28

Means within the same row lacking common letters (a,b) differ ($P < 0.05$).

Conclusions

In conclusion, injecting round muscles with a salt and phosphate solution improved most palatability traits compared to those that were blade tenderized or were not treated. For the most part, cooking method and degree of doneness had little influence on consumer palatability ratings. Where differences occurred, they were muscle specific, which may allow limited recommendations for certain muscles with respect to the most appropriate cooking method and degree of doneness.

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