The Journal of Undergraduate Research

Volume 4 *Journal of Undergraduate Research, Volume 4: 2006*

Article 7

2006

Trained and Consumer Evaluations of Five Different Beef Muscles with or without pH Enhancement using Ammonium Hydroxide

Tim Nath

South Dakota State University

Trained and Consumer Evaluations of Five Different Beef Muscles with or without pH Enhancement using Ammonium Hydroxide

Author: Tim Nath
Faculty Sponsor: Dr. Duane Wulf
Department: Animal Science

ABSTRACT

Research was conducted in two phases: first to determine optimal pump percentage for each of five pH-enhanced beef muscles and then to determine the effect of pH enhancement on consumer acceptability of beef steaks. Phase I was a 5 x 4 factorial design with five muscles: longissimus lumborum (LL), gluteus medius (GM), triceps brachii (TB), biceps femoris (BF), and psoas major (PM) and four pump percentages: 0, 10, 20, and 30% to determine optimum pump percentage for each muscle using an 8-member trained sensory panel. Phase II was a 5 x 2 factorial design with the same five muscles and two treatments: control (CON) and pH-enhanced (PHE) to quantify desirability using a 182-member central-location consumer panel. Muscles designated for pH enhancement were injected with a solution containing water, ammonium hydroxide, and salt (technology patented by Freezing Machines, Inc.). All muscles were stored in vacuum packages, cut into 2.5-cm-thick steaks, and cooked to 71°C on electric clam-shell grills for the trained panel and gas grills for the consumer panel. Purge loss and pH were measured on raw muscles. Cooking loss, calculated moisture retained after cooking, and Warner-Bratlzer shear force (WBS) were measured on cooked steaks. In Phase I, pH increased, purge loss increased, calculated moisture retained after cooking increased, and WBS decreased for all muscles as pump percentage increased from 0 to 30% ($P < 0.05$), except that WBS of BF was not affected by pump percentage ($P = 0.55$). Juiciness and tenderness of LL increased as pump percentage increased from 0 to 30% ($P < 0.05$), but 30% pump resulted in a slightly non-meat texture and slight off-flavors ($P < 0.05$). Juiciness, tenderness, and beef flavor intensity of GM was greatest at 20% pump compared to other pump percentages ($P < 0.05$). Juiciness and tenderness of TB was greater at 30% pump than at other pump percentages ($P < 0.05$), but 30% pump also caused more non-meat textures in TB than other pump percentages ($P < 0.05$). Juiciness of BF was greater at 30% pump than at other pump percentages ($P < 0.05$), and tenderness of BF was greater at 20 and 30% pump compared to 0 and 10% pump ($P < 0.05$). Tenderness of PM increased as pump percentage increased from 10 to 30% ($P < 0.05$). Based on Phase I results, we determined optimum pump percentages were 15% for LL, 20% for GM, 10% for TB, 30% for BF, and 15% for PM, which were used for PHE in Phase II. Consumer ratings for 'overall like' were higher for PHE than CON for LL

(7.70 vs. 6.64), GM (7.40 vs. 6.10), and BF (5.09 vs. 4.14) ($P < 0.05$). For LL, GM, and BF, consumers rated PHE higher than CON for 'like of tenderness/texture', 'like of juiciness', and 'like of flavor' ($P < 0.05$). For PHE vs. CON, respectively, percentage of consumers responding 'yes' to "Would you be satisfied with this steak if you had eaten it in a restaurant?" was 80 vs. 65% for LL ($P < 0.05$), 74 vs. 47% for GM ($P < 0.05$), 59 vs. 49% for TB ($P < 0.05$), 31 vs. 20% for BF ($P < 0.05$), and 73 vs. 81% for PM ($P = 0.10$). In conclusion, different muscles had different optimum pump percentages for pH enhancement, and pH enhancement improved consumer acceptability in some muscles (LL, GM, and BF) more than others (TB and PM).

INTRODUCTION

Product quality and consistency has been identified as a high priority for beef consumers (NCBA, 1998) and beef consumers are willing to pay higher prices for greater tenderness (Boleman et al., 1997). However, there is a significant portion of beef cuts that are "unacceptable" in tenderness (Brooks et al., 2000). Pork processors have been using injection of various formulations of water, sodium tripolyphoshate, sodium/potassium lactate, sodium chloride, and flavorings to enhance and maintain the tenderness, juiciness, and flavor of lean pork (Vote et al., 2000). Injecting beef strip loins with sodium tripolyphosphate, sodium lactate, and sodium chloride has been shown to improve tenderness (Vote et al., 2000). pH enhancement with ammonium hydroxide has also shown to improve the palatability of beef strip loins (Hand et al., 2005). Both Vote et al. (2000) and Hand et al. (2005) reported improved tenderness in the beef longissimus, a tender muscle, but the effect of pH enhancement with ammonium hydroxide on muscles that are less tender has not been reported. Therefore, research was conducted in two phases first to determine optimal pump percentage for each of five pH-enhanced beef muscles and then to determine the effect of pH enhancement on consumer acceptability of beef steaks.

MATERIALS & METHODS

Treatments

The experimental design for Phase I consisted of treatments in a 5 x 4 factorial with five muscles: longissimus lumborum (LL), gluteus medius (GM), triceps brachii (TB), biceps femoris (BF), and psoas major (PM), and four pump percentages: 0, 10, 20, and 30%. The experimental design for Phase II consisted of treatments in a 5 x 2 factorial with five muscles: LL, GM, TB, BF, and PM, and two treatments: control (CON) and pH-enhanced (PHE).

Enhancement

USDA Select subprimals of beef were purchased as boxed beef though normal purchasing practices. Each muscle had 48 subprimals which were randomly selected for each pump treatment {0% (n=9), 10% (n=13), 20% (n=13) and 30% (n=13)}. Muscles designated for pH enhancement were injected (Day 0) with a solution containing water, ammonium hydroxide, and salt (technology patented by Freezing Machines, Inc. Dakota Dunes, SD). After the meat was enhanced, all muscles were stored in vacuum sealed bags and transported to the South Dakota State University Meat Laboratory for data collection.

Data Collection

Purge loss was measured and a percent loss was recorded for every subprimal (LL-Day 3, GM-Day 3, TB-Day 4, BF-Day 5 & 6, and PM-Day 6). An instrumental pH (MPI pH Meter, Pelican 1450, Torance, CA) meter was used to measure the pH of every subprimal (LL-Day 10, GM-Day 4, TB-Day 4, BF-Day 6, and PM-Day 6). Steaks for WBS (G-R Manufacturing Co., Manhattan, KS) were weighed before and after cooking to determine percent cooking loss (LL-Day 6, GM-Day 7, TB-Day 5, BF-Day 7, and PM-Day 7) and percent moisture retained was calculated {(72+Pump%-(Purge%/100*(100+Pump%))-(Cookloss%/100*(100+Pump%-(Purge%/100*(100+Pump%)))))/((100+Pump%-(Purge%/100*(100+Pump%)))*((100-Cookloss%)/100))*100} on cooked steaks. Steaks for WBS were cooked an electric clam-shell grill (George Foreman Indoor/Outdoor Grill, Model GGR62, Lake Forest, IL) to 71°C internally and then allowed to equilibrate to room temperature before shear force was measured. Four subprimals for each target pump percentage for each muscle, closest to the pump percentage target (0, 10, 20, and 30%), were designated for panels with the actual pump percentage means being 0, 10.1, 20.2, and 30.1% for the LL; 0, 10, 19.9, and 29.6% for the GM; 0, 10.1, 19.9, and 29.9% for the TB; 0, 10, 19.7, and 29.4% for the BF; 0, 10.3, 19.9, and 29.3% for the PM, respectively.

Cutting Specifications

Each muscle had its own cutting specifications with all steaks cut 2.5 cm thick and exterior fat removed. Strip loin samples consisted of only LL. Strip loins were faced on the anterior end. The first LL steak removed was used for WBS, the next two steaks removed were for trained panel, and if needed the next four steaks removed were used for consumer panel. Top sirloin samples consisted of only GM. The first 5 cm from the posterior end were removed and discarded from the top sirloin. The first GM steak removed was used for WBS and trained panel and if needed the next two steaks removed were used for consumer panel. Shoulder clod samples consisted of only TB. The first three inches from the posterior side were removed and discarded from the shoulder clod. The first TB steak removed was used for WBS and trained panel and if needed the next two steaks removed were used for consumer panel. Bottom round samples consisted of only BF. Approximately 10 cm was removed from the bottom round and discarded. The first BF steak removed was used for WBS and trained panel and if needed the next two steaks removed were used for consumer panel. Tenderloin samples consisted only of PM. The Psoas minor and approximately 7.5 cm from the butt end were removed and discarded from the tenderloin. The first PM steak removed was used for WBS and the next two steaks removed were used for trained panel and if needed the next four steaks removed was used for consumer panel.

Taste Evaluations

Steaks for trained panel were cooked on an electric clam-shell grill to 71°C internally. The steaks were cut into 2.5 x 1.3 cm pieces using a sizing guide. The samples were then placed into Styrofoam bowls with holes punched in the bottom to allow juices to drain, covered with aluminum foil, and held in a 60∞C warming oven until served. Panels were conducted in booths preventing panelist interaction. Prior to the start of the panel, panelists were given brief instructions about panel procedure and were asked to sign a notice of informed consent. All samples were served under red lights to limit differences in visual appearance. Four different samples of each treatment (0, 10, 20, and 30%) were served in a random order to the panel. The samples were numbered 1 to 16 for the trained panel. Steaks for the consumer panels were cooked on a gas grill (Weber Silver A Gas Grill, Palatine, IL) to 71°C internally. The steaks were then cut and prepared for serving as explained above. The samples were coded with a random code to blind consumers to treatment combinations.

Panels

Trained and consumer panels were conducted according to standards set by the American Meat Science Association (AMSA, 1995). Panelists were recruited from the Brookings, SD area using newspaper advertising. Eight trained panelists evaluated a muscle each day (LL-Day 3, GM-Day 4, TB-Day 5, BF-Day 6, and PM-Day 7). Data collected from trained panelist was used to determine optimal pump percentage of each muscle. One hundred eighty-two consumers participated in nine different panel times to evaluate beef palatability for control and enhanced steaks.

RESULTS

Data Collection (Figures 1-5). Figure 1 shows that as pump percentage increased, pH increased from approximately 5.75 at 0% to 6.25 at 30%. Overall, the ammonium hydroxide enhancement raised the pH of each cut about 0.15 for every 10% pump percentage increase.

Figure 2 shows that as pump percentage increased, WBS decreased for the LL, GM, TB, and PM ($P<0.05$), but had no significant affect on BF ($P=0.55$).

Figure 3 shows that as pump percentage increased, purge loss increased for all muscles ($P<0.05$), but purge loss for TB decreased over 25% pump. GM had the highest purge loss of all subprimals.

Figure 4 shows that pump percentage had no significant affect on cooking loss for GM ($P=0.30$). As pump percentage increased, cooking loss increased for BF and decreased for LL. PM increased in cooking loss as pump percentage increased until 10%,

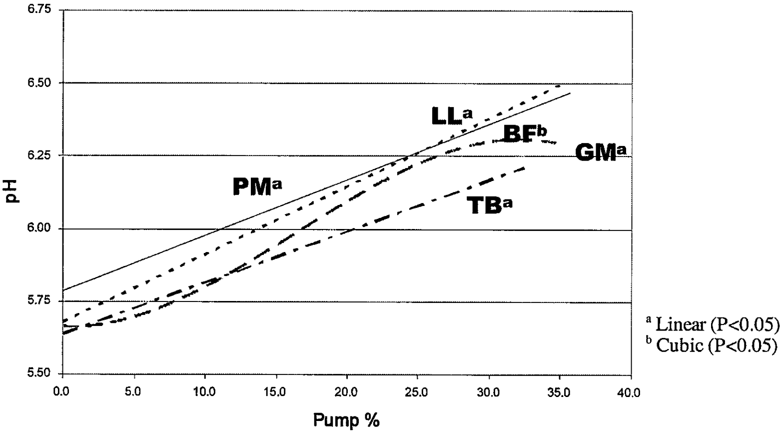

Figure 1. Effect of pump percentage on muscle pH.

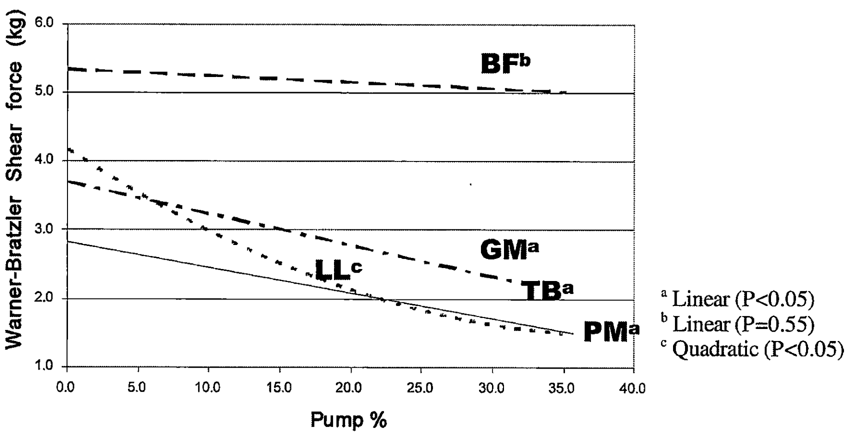

Figure 2. Effect of pump percentage on Warner-Bratlzer shear.

then held constant until 25% and then increased again. TB cooking loss increased as pump percentage increased up to 15% and then decreased.

Figure 5 shows that as pump percentage increased, calculated % moisture retained increased for all muscles, but calculated % moisture retained for PM decreased after 30.0%. LL had the greatest change for calculated % moisture retained for all muscles.

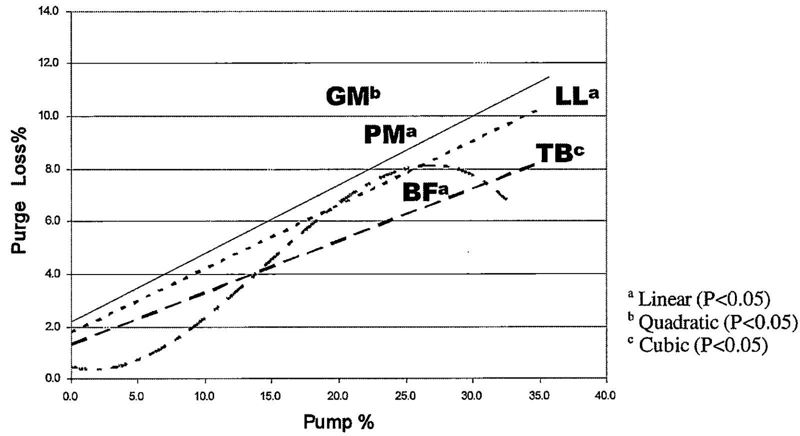

Figure 3. Effect of pump percentage on purge loss %.

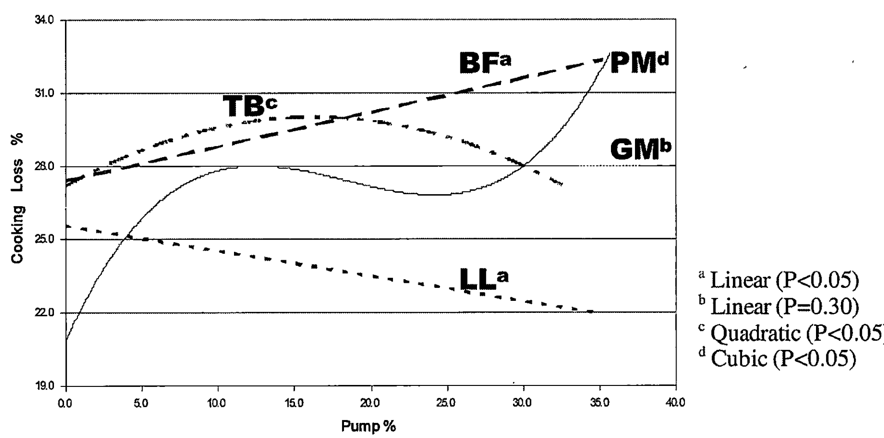

Figure 4. Effect of pump percentage on cooking loss %.

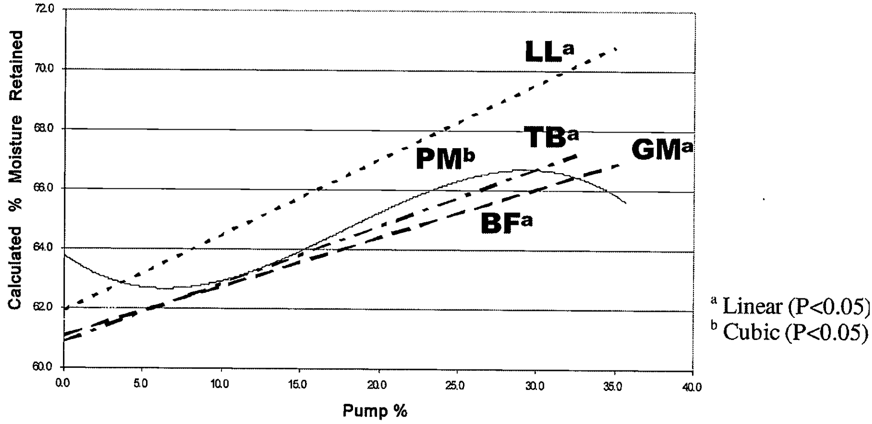

Figure 5. Effect of pump percentage on calculated % moisture.

Trained Panel (Table 1)

Juiciness and tenderness of LL increased as pump percentage increased from 0 to 30% (P < 0.05), but 30% pump resulted in a slightly non-meat texture and slight off-flavors (P < 0.05). The 10 and 20% pumped LL steaks had the highest ratings for meat texture, beef flavor intensity, and overall desirability. Juiciness, tenderness, and beef flavor intensity of GM was greatest at 20% pump compared to other pump percentages (P < 0.05). Juiciness and tenderness of TB was greater at 30% pump than at other pump percentages (P < 0.05), but 30% pump also caused more non-meat textures in TB than other pump percentages (P < 0.05). The 10% pumped TB steaks rated the highest for overall desirability and also rated high for juiciness and tenderness. Juiciness of BF was greater at 30% pump than at other pump percentages (P < 0.05), and tenderness of BF was greater at 20 and 30% pump compared to 0 and 10% pump (P < 0.05). The 0 and 10% pumped BF steaks were the least desired in most categories. Tenderness of PM increased as pump percentage increased from 10 to 30% (P < 0.05). The 30% pumped PM steaks were the highest in juiciness and tenderness. However, 20% and 30% pumped PM steaks rated the lowest for meat texture. Based on Phase I results, we determined optimum pump percentages were 15% for LL, 20% for GM, 10% for TB, 30% for BF, and 15% for PM, which were used for PHE in Phase II.

Table 1. Effect of pump percentage on trained panel ratings.

Longissimus lumborum	0%	10%	20%	30%
Juiciness^{v}	5.08^{a}	5.21^{a}	5.54^{a}	6.38^{b}
Tenderness^{w}	4.46^{a}	5.38^{b}	5.75^{b}	7.25^{c}
Meat Texture^{x}	3.92^{b}	3.96^{b}	3.79^{b}	3.04^{a}
Beef Flavor Intensity^{y}	5.13	5.42	5.63	5.33
Off Flavor^{z}	3.92^{ab}	4.00^{b}	3.92^{ab}	3.46^{a}
Gluteus medius	**0%**	**10%**	**20%**	**30%**
Juiciness^{v}	5.22^{a}	5.44^{a}	6.22^{b}	5.53^{a}
Tenderness^{w}	4.28^{a}	5.75^{b}	6.31^{c}	5.69^{b}
Meat Texture^{x}	4.00^{c}	3.97^{bc}	3.88^{ab}	3.84^{a}
Beef Flavor Intensity^{y}	5.28^{a}	5.34^{ab}	5.69^{b}	5.47^{ab}
Off Flavor^{z}	3.75^{a}	3.94^{b}	3.84^{ab}	3.84^{ab}
Triceps brachii	**0%**	**10%**	**20%**	**30%**
Juiciness^{v}	5.18^{ab}	5.59^{bc}	5.13^{a}	5.84^{c}
Tenderness^{w}	5.07^{a}	5.56^{a}	5.31^{a}	6.16^{b}
Meat Texture^{x}	3.97^{b}	4.00^{b}	3.97^{b}	3.63^{a}
Beef Flavor Intensity^{y}	5.14	5.41	5.41	5.25
Off Flavor^{z}	3.94	3.97	3.84	3.84
Biceps femoris	**0%**	**10%**	**20%**	**30%**
Juiciness^{v}	5.00^{a}	5.05^{a}	5.22^{a}	5.53^{b}
Tenderness^{w}	4.00^{a}	4.27^{a}	5.16^{b}	5.13^{b}
Meat Texture^{x}	4.00	4.00	3.97	3.94
Beef Flavor Intensity^{y}	4.94	5.16	5.22	5.34
Off Flavor^{z}	3.91	3.92	3.94	3.94
Psoas major	**0%**	**10%**	**20%**	**30%**
Juiciness^{v}	5.22	5.34	5.44	5.50
Tenderness^{w}	6.53^{a}	6.59^{a}	7.00^{b}	7.44^{c}
Meat Texture^{x}	4.00^{b}	4.00^{b}	3.84^{ab}	3.78^{a}
Beef Flavor Intensity^{y}	5.69	5.56	5.44	5.28
Off Flavor^{z}	3.91	3.74	3.97	3.94

^{v} Trained Ratings (1=Extremely Dry, 8= Extremely Juicy)
^{w} Trained Ratings (1=Extremely Tough, 8=Extremely Tender)
^{x} Trained Ratings (1=Extremely Non-Meat, 4=Meat-Like Texture)
^{y} Trained Ratings (1=Extremely Bland, 8= Extremely Intense)
^{z} Trained Ratings (1=Extreme Off-Flavor, 4=No Off Flavor)
^{a,b,c,d} Means within a row lacking a common superscript differ ($P<0.05$).

Consumer Demographics (Table 2)

A wide range of consumer types were represented in the consumer panel (Table 2). A higher-than-normal proportion of young (18 to 29) consumers were sampled.

Table 2. Demographic profile of 182 consumer taste panelists.

	Number of Consumers	% of Consumers
Age		
Under 22 Years	49	27%
22 to 29	60	33%
30 to 39	19	10%
40 to 49	16	9%
50 to 59	16	9%
60 or older	21	12%
Household Income		
Under $20 K	104	58%
$20 to $29 K	19	10%
$30 to $39 K	10	6%
$40 to $49 K	10	6%
$50 to $59 K	16	9%
$60 K or higher	21	11%
Gender		
Male	96	53%
Female	86	47%

	Number of Consumers	% of Consumers
Working Status		
Not employed	31	17%
Part-time	32	18%
Full-time	66	36%
Student	53	29%
Times per Week Beef is Consumed		
0 to 1	14	8%
2 to 3	59	33%
4 to 5	69	38%
>5	39	21%
Times per Month Steak is Consumed		
0 to 1	31	17%
2 to 3	75	42%
4 to 5	44	24%
>5	31	17%

Consumer Panels (Table 3)

Enhancement with ammonium hydroxide improved the 'overall like' of LL, GM, and BF, but had little effect on TB and PM. These results support the findings of Hand et al. (2005) who reported enhanced LL was rated higher than non-enhanced LL. 'Like of tenderness' was improved by pH enhancement most notably in LL, but also in GM and BF, and slightly improved in TB. 'Like of juiciness' was improved by pH enhancement in LL, GM, and BF. Control tenderloin rated slightly higher than pH-enhanced tenderloin for 'like of juiciness'. 'Like of flavor' was improved by pH enhancement in LL, GM, and BF, with the largest flavor improvement in GM. pH enhancement resulted in an increased interest in purchasing for LL, GM, TB, and BF. Control PM rated higher for intent-to-purchase than pH-enhanced PM. Enhancement with ammonium hydroxide resulted in a higher percentage of satisfied consumers for all muscles except the PM.

Table 3. Effect of pump percentage on consumer panel ratings.

Longissimus lumborum	Control	Enhanced	p value
Overall Like[x]	6.64	7.70	0.0001
Tenderness/Texture[x]	6.56	8.18	0.0001
Juiciness[x]	6.07	7.13	0.0001
Flavor[x]	6.53	7.33	0.0006
Buy?[y]	0.68	0.81	0.0054
Eat?[z]	0.65	0.80	0.0031
Gluteus medius	Control	Enhanced	p value
Overall Like[x]	6.10	7.40	0.0001
Tenderness/Texture[x]	6.00	7.10	0.0001
Juiciness[x]	5.92	7.01	0.0001
Flavor[x]	6.10	7.50	0.0001
Buy?[y]	0.60	0.81	0.0001
Eat?[z]	0.47	0.74	0.0001
Triceps brachii	Control	Enhanced	p value
Overall Like[x]	6.30	6.50	0.3501
Tenderness/Texture[x]	6.12	6.46	0.1381
Juiciness[x]	6.13	6.18	0.8048
Flavor[x]	6.12	6.51	0.0897
Buy?[y]	0.55	0.66	0.0169
Eat?[z]	0.49	0.59	0.0252
Biceps femoris	Control	Enhanced	p value
Overall Like[x]	4.14	5.09	0.0001
Tenderness/Texture[x]	3.42	4.14	0.0015
Juiciness[x]	4.25	5.53	0.0001
Flavor[x]	4.73	5.70	0.0001
Buy?[y]	0.20	0.38	0.0002
Eat?[z]	0.20	0.31	0.0268
Psoas major	Control	Enhanced	p value
Overall Like[x]	7.87	7.60	0.2129
Tenderness/Texture[x]	8.60	8.53	0.7519
Juiciness[x]	7.60	7.15	0.0428
Flavor[x]	7.34	7.10	0.2997
Buy?[y]	0.82	0.72	0.0327
Eat?[z]	0.81	0.73	0.1026

[x] Consumer Ratings (1=Dislike Extremely, 10=Like Extremely)

[y] Consumer were asked "Would you purchase this product from a retail grocery store?" (Value is the percentage that said YES).

[z] Consumer were asked "Would you be satisfied with this steak if you had eaten it in a restaurant?" (Value is the percentage that said YES).

CONCLUSION

Meat pH increased, purge loss increased, calculated moisture retained after cooking increased, and Warner-Bratlzer shear force decreased for all muscles as pump percentage increased from 0 to 30% ($P < 0.05$), except that Warner-Bratlzer shear force of biceps femoris was not affected by pump percentage ($P = 0.55$). Our findings showed different muscles had different optimum pump percentages for pH enhancement, and pH enhancement improved consumer acceptability in some muscles (longissimus lumborum, gluteus medius, and biceps femoris) more than others (triceps brachii and psoas major).

ACKOWLEDGEMENTS

Funding for this research was provided by the Griffith Undergraduate Research Scholarship and BPI Technology of Dakota Dunes, South Dakota. I would like to thank Carissa Hand, Amanda Everts, and Andrew Everts for their help with the data collection and taste panels.

REFERENCES

AMSA. 1995. Research guidelines for cookery, sensory evaluation, and tenderness measurements of fresh meat. Am. Meat Sci. Assoc., Chicago, IL.

Boleman, S. J., S. L. Boleman, , R. K. Miller, J.F. Taylor, H. R. Cross, T. L. Wheeler, M. Koohmaraie, S. D. Shankelford, M. F. Miller, R. L. West, and D. D. Johnson, J. W. Savell. 1997. Consumer evaluation of beef of known categories of tenderness. J. Anim. Sci. 75:1521-1524

Brooks, J.C., J. B. Belew, D. B. Griffin, B. L. Gwartney, D. S. Hale, W. R. Henning, D. D. Johnson, J. B. Morgan, F. C. Parrish, Jr, J. O. Reagon, and J. W. Savell. National Beef Tenderness Survey. J. Anim. Sci. 78-1852-1860.

Hand, C.D., D. M. Wulf, R. J. Maddock. 2005. Using pH-enhancement of beef steaks to improve customer satisfaction. Proc. 51st Int. Congr. Meat Sci. Technol., Baltimore, MD.

NCBA. 1998. Beef Industry Long Range Plan. National Cattlemen's Beef Association, Englewood, CO.

Vote, D. J., W. J. Platter, J. D. Tatum, G. R. Schmidt, K. E. Belk, G. C. Smith, and N. C. Speer. 2000. Injection of beef strip loins with solutions containing sodium tripolyphosphate, sodium lactate, and sodium chloride to enhance palatability. J. Anim. Sci. 2000. 78:952-957.