2-2004

Evaluating Consumer Acceptability of Various Muscles From the Beef Chuck and Rib

A.C. Kukowski
South Dakota State University

R.J. Maddock
South Dakota State University

D.M. Wulf
South Dakota State University

Evaluating consumer acceptability of various muscles from the beef chuck and rib[1]

A. C. Kukowski, R. J. Maddock[1], and D. M. Wulf

South Dakota State University, Brookings 57007

ABSTRACT: One hundred thirty-eight consumers evaluated steaks from the complexus (CX), infraspinatus (IF), serratus ventralis (SV), supraspinatus (SS), and triceps brachii (TB) from the wholesale beef chuck; the deep pectoral (DP) from the wholesale brisket; and the longissimus thoracis (LT) from the wholesale rib. The LT was used as a reference for comparison to the other muscles. Ten USDA Choice and ten USDA Select boneless boxed beef subprimals were used for each muscle. Subprimals were aged 14 d from box date, frozen, and cut into 2.5-cm-thick steaks. Consumers rated the IF highest ($P < 0.05$) for overall like, tenderness, juiciness, and flavor, and assigned it the highest ($P < 0.05$) price/0.45 kg. The TB also was rated higher ($P < 0.05$) than the LT for overall like, tenderness, juiciness, flavor, and price/0.45 kg. The SV and CX were rated as being similar ($P < 0.05$) to the LT for overall like, tenderness, juiciness, flavor, and price/0.45 kg. Consumers rated the SS lower ($P < 0.05$) than the LT for tenderness, juiciness, flavor, and price. The DP was rated as the toughest, driest, and blandest ($P < 0.05$), resulting in assignment of the lowest ($P < 0.05$) price/0.45 kg. Differences in palatability ratings due to quality grade were found for several muscles; USDA Choice SV and SS were rated higher ($P < 0.05$) for overall like, tenderness, and juiciness than USDA Select SV and SS. For the IF, USDA Choice was rated higher ($P < 0.05$) for tenderness and juiciness than USDA Select. The USDA Choice TB was rated higher ($P < 0.05$) for juiciness, and the USDA Choice DP was rated higher ($P < 0.05$) for overall like, than their USDA Select counterparts. Tenderness, juiciness, and flavor ratings were correlated with overall like ratings (r = 0.84, 0.77, and 0.76, respectively) and with price (r = 0.73, 0.70, and 0.68, respectively). These results indicate the IF, TB, SV, and CX were acceptable, whereas and the SS and DP were unacceptable as steaks.

Key Words: Beef, Chuck, Consumers, Muscles, Palatability, Value

 J. Anim. Sci. 2004. 82:521–525

Introduction

In the last decade, consumer demand for the more tender middle cuts of beef (rib and loin) has increased, whereas demand for the tougher end cuts of beef (chuck and round) has decreased. This is shown by an increasing retail price spread between middle cuts and end cuts (Bureau of Labor Statistics, 2002). The increased demand for middle cuts, combined with decreased demand for end meats, has resulted in the average retail beef prices remaining relatively unchanged during the 1990s.

Traditionally, the beef chuck has been merchandised in the form of low-priced roasts. According to Purcell (1993), families with more than one wage earner have significantly decreased their consumption of beef chuck roasts, probably due to the time required to prepare a roast. In addition, consumers in higher-educated and high-income groups feel they don't know how to prepare a chuck roast (Purcell, 1993). As a result of these factors, consumers purchase far less roasts compared to steaks according to Medina and Ward (1999), who reported that 24.8% of beef purchases in the grocery store were roasts as opposed to 54.0% that are purchased as steaks. Menkaus et al. (1993) reported that 55.3% of consumers surveyed were concerned that beef was tough, and the National Beef Tenderness Surveys (Morgan et al., 1991; Brooks et al., 2000) indicated, in general, that chuck and round subprimals were tougher than middle meats.

Several studies (Ramsbottom et al., 1945; Johnson et al., 1988; NCBA, 2000) have documented palatability traits of the major muscles of the beef chuck with the use of trained sensory panels and objective tenderness measurements. These studies showed that some of the larger chuck muscles might be suitable for use as steaks

[1]This research was funded in part by the South Dakota Beef Industry Council. This paper is technical article 3363 of the South Dakota State Univ. Exp. Stn.

[2]Correspondence: Box 2170 (phone: 605-688-5439; fax: 605-688-6170; e-mail: robert_maddock@sdstate.edu).

Received March 28, 2003.

Accepted October 16, 2003.

rather than as roasts. However, there is limited knowledge about consumer preference of chuck muscles. Therefore, the objective of this study was to evaluate consumer preference and determine value of various muscles from the beef chuck and rib.

Materials and Methods

Muscle Treatment

The complexus (**CX**), infraspinatus (**IF**), serratus ventralis (**SV**), supraspinatus (**SS**), and triceps brachii (**TB**) from the wholesale beef chuck; the deep pectoral (**DP**) from the beef wholesale brisket; and the longissimus thoracis (**LT**) from the wholesale rib were obtained from ten USDA Choice and ten USDA Select boxed beef subprimals from a commercial packing plant. Muscles were aged 14 d from the date on box in a 0 to 2°C cooler, and frozen at –26°C. Frozen muscles were then cut into 2.5-cm-thick steaks on a band saw, vacuum-packaged, randomized into groups for consumer panel evaluation, and stored at –26 to –30°C until used (approximately 3 mo).

Steak Preparation

Steaks were thawed for 24 h in a 0 to 2°C cooler and broiled on Farberware Open Hearth electrical broilers (Farberware, Bronx, NY). The metal housing and drip pans of each broiler were covered with aluminum foil and preheated for 15 min. During cooking, all steaks were turned every 4 min during broiling until an internal temperature of 71°C was reached (medium degree of doneness). A digital thermometer (Atkins Technical Inc., Gainesville, FL) placed in the approximate geometric center of each steak was used to monitor internal temperature. After cooking, steaks were wrapped in aluminum foil and held in a warming oven (PM 2X 500 Proofer Model, Metro, Wilkes-Barre, PA) for approximately 5 to 10 min. Steaks were cut into 1.3 cm × 2.5 cm × cooked thickness of the steak cubes and were served to consumer panelists. Consumers were unaware of which muscle they were eating, and the order in which muscles were served to panelists was randomized separately for each panel such that each muscle was served in a different order for each panel.

Consumer Panel

Twelve panels consisting of 10 to 12 panelists each, for a total of 138 consumers, were recruited from the South Dakota State University campus and Brookings, SD, populations. Panelists were sequestered into individual booths under red incandescent lights, given a cup of distilled water and several unsalted crackers, and given minimal instructions. Among the instructions given were that they were eating beef samples, to use the numbers provided by the panel moderator when reporting their preferences, and to take a drink of water and a bite of cracker between each sample. Demographic questionnaires were completed before sampling. Panelists each rated 14 samples (USDA Choice and Select steaks from each of the seven muscles) for overall like, tenderness, juiciness, and flavor on 10-point scales with anchored end points (1 = dislike extremely, extremely tough, dry, or bland to 10 = like extremely, extremely tender, juicy, or intense). Panelists also assigned a price/0.45 kg for each sample on a 0- to-10 scale (0 = would not buy, 10 = $10/0.45 kg). Current retail prices for various beef cuts were given as a guideline in assigning a price/0.45 kg for each sample. On completion of the sensory evaluation, panelists were given $10 in cash.

Statistical Analysis

Data were analyzed to determine the difference in consumer ratings of steaks using the GLM procedure of SAS (SAS Inst., Cary, NC) as a completely randomized design with muscle and quality grades as the main effects. Least squares means calculated for overall like, tenderness, juiciness, flavor, and price/0.45 kg were separated using pairwise *t*-tests (PDIFF option). Correlations among overall like and palatability traits, and overall like and price, were calculated across all muscles using the correlation procedure of SAS.

Results and Discussion

Consumer Panelist Demographics

Demographic data for this study are summarized in Table 1. Panelists were mostly male, college-aged individuals with low incomes (<$20,000 annual income), who frequently consumed beef (85.57% of the panelists consumed beef four or more times a week).

Consumer Panel Ratings for Tenderness

The IF was rated as the most ($P < 0.05$) tender muscle, and similar ($P > 0.05$) to the TB, SV, and CX (Table 2). The SS was rated tougher ($P < 0.05$) than the LT, and the DP was the toughest ($P < 0.05$) muscle. In general, Choice-graded muscles were rated higher ($P < 0.05$) for tenderness than Select muscles. The SS, SV, and IF from USDA Choice chucks were rated more tender than those from USDA Select chucks, respectively (muscle type × quality grade; $P < 0.05$); however, consumers did not ($P > 0.05$) detect differences in tenderness between USDA Choice and Select DP, CX, LT, and TB. According to results of a beef-profiling study (NCBA, 2000), with the exception of the SS, most chuck muscles from USDA Choice carcasses have greater amounts of intramuscular fat than cattle graded USDA Select. Therefore, increased amounts of marbling may have resulted in increased tenderness ratings for USDA Choice SV and IF but cannot explain the differences found in the SS. According to Brooks et al. (2000), quality grade group

Table 1. Frequencies for consumer demographic information

Variable	Frequency[a]
Age	
Less than 20 yr	24.95%
20 to 29 yr	61.75%
30 to 39 yr	5.82%
40 to 49 yr	4.49%
50 to 59 yr	2.99%
Greater than 60 yr	0.00%
Annual income level	
Less than $20,000	82.37%
$20,000 to $29,000	5.98%
$30,000 to $39,000	2.83%
$40,000 to $49,000	1.34%
$50,000 to $59,000	4.49%
Greater than $60,000	2.99%
Work status	
Not employed	4.49%
Part-time	21.26%
Full-time	13.14%
Student	61.11%
Weekly beef consumption	
Three or fewer times per week	14.43%
Four to seven times per week	50.00%
Eight or more times per week	35.57%
Sex	
Male	68.32%
Female	31.68%

[a]Frequency expressed as percentage of consumers (n = 138).

did not affect shear force of beef chuck steaks. Findings for tenderness of the IF and DP (IF was more tender than the LT, and DP was tougher than the LT) agree with several studies that evaluated the tenderness of various chuck muscles using trained sensory panels and mechanical tenderness measurements (Paterson and Parrish 1986; Johnson et al., 1988; NCBA, 2000).

Consumer Panel Ratings for Juiciness

The IF was rated as the juiciest ($P < 0.05$) muscle, and the TB, SV, and CX were rated higher ($P < 0.05$) for juiciness than the LT (Table 2). Consumers rated the SS similar ($P > 0.05$) to LT for juiciness, and the DP was rated as the driest ($P < 0.05$) muscle. Quality grade was significant for juiciness ratings, with USDA Choice muscles generally rating higher ($P < 0.05$) for juiciness than USDA Select muscles. Muscle type × quality grade interaction ($P < 0.0028$) was noted for juiciness, with consumers rating USDA Choice SS, SV, TB, and IF more juicier than their USDA Select counterparts, but they failed to discern differences in juiciness between USDA Choice and Select DP, LT, and CX. Neely et al. (1998) and Lorenzen et al. (1999) demonstrated that, as marbling increased, juiciness ratings also increased. As fat content is increased, there tends to be more juice (fat) retained in the steak during cooking, resulting in higher ratings for juiciness. (Smith et al., 1984)

Table 2. Least squares means (±SE) for palatability traits of beef chuck and rib muscles[a] by quality grade (n = 138)

	USDA Choice						USDA Select						*P*-value		
Trait	IF	TB	SV	CX	LT	SS	DP	IF	TB	SV	CX	LT	SS	DP	Muscle	Grade	M × G[b]
Overall Like[c]	7.59^{e} ± 0.17	7.00^{fg} ± 0.17	6.97^{fg} ± 0.17	6.76^{ghij} ± 0.18	6.42^{hij} ± 0.17	6.22^{ijk} ± 0.19	4.23^{j} ± 0.17	7.27^{ef} ± 0.17	6.88^{fgh} ± 0.17	6.39^{ijk} ± 0.17	6.40^{hij} ± 0.18	6.62^{ghijk} ± 0.17	5.50^{l} ± 0.19	4.72^{m} ± 0.17	<0.0001	0.0417	0.0072
Tenderness[c]	8.12^{e} ± 0.19	6.85^{g} ± 0.19	6.75^{g} ± 0.18	6.40^{ghij} ± 0.19	6.42^{ghi} ± 0.19	5.92^{ij} ± 0.20	3.22^{l} ± 0.19	7.59^{f} ± 0.19	6.74^{g} ± 0.19	5.88^{i} ± 0.19	6.13^{hij} ± 0.19	6.86^{g} ± 0.19	5.12^{k} ± 0.20	3.71^{l} ± 0.19	<0.0001	0.0266	0.0003
Juiciness[c]	7.36^{e} ± 0.18	6.70^{f} ± 0.18	6.61^{fg} ± 0.17	6.49^{fgh} ± 0.19	5.41^{ij} ± 0.18	5.53^{i} ± 0.20	4.20^{k} ± 0.18	6.75^{f} ± 0.18	6.14^{gh} ± 0.18	6.09^{h} ± 0.18	6.27^{fgh} ± 0.19	5.52^{ij} ± 0.18	4.46^{k} ± 0.20	4.66^{k} ± 0.18	<0.0001	0.0001	0.0028
Flavor[c]	7.13^{e} ± 0.17	6.96^{ef} ± 0.17	6.75^{efg} ± 0.17	6.49^{ghi} ± 0.18	6.05^{hi} ± 0.17	5.99^{hi} ± 0.19	4.69^{k} ± 0.17	6.67^{efg} ± 0.17	6.63^{fg} ± 0.17	6.47^{ghi} ± 0.17	6.37^{ghi} ± 0.18	6.01^{hi} ± 0.17	5.46^{j} ± 0.19	5.14^{jk} ± 0.17	<0.0001	0.0632	0.0889
Price[d]	6.01^{e} ± 0.19	5.20^{fg} ± 0.19	4.95^{fghij} ± 0.18	4.91^{fghij} ± 0.19	4.55^{jk} ± 0.19	4.33^{k} ± 0.20	2.73^{m} ± 0.19	5.35^{f} ± 0.19	5.09^{fghi} ± 0.19	4.57^{jk} ± 0.19	4.60^{hijk} ± 0.19	4.59^{ijk} ± 0.19	3.69^{l} ± 0.20	2.99^{m} ± 0.19	<0.0001	0.1393	0.1359

[a]IF = infraspinatus, TB = triceps brachii, SV = serratus ventralis, CX = complexus, LT = longissimus thoracis, SS = supraspinatus, and DP = deep pectoral.
[b]M × G = muscle type × quality grade interaction.
[c]Rated on a 10-point scale (1 = dislike extremely, extremely tough, extremely dry, and extremely bland to 10 = extremely tender, extremely juicy, and extremely intense.)
[d]Price (U. S. $/0.45 kg) based on a 10-point scale (0 = would not buy to 10 = $10/0.45 kg).
[e,f,g,h,i,j,k,l,m]Means within a row that do not have a common superscript differ ($P < 0.05$).

Consumer Panel Ratings for Flavor

The IF and TB had the most ($P < 0.05$) intense flavor ratings, and the SV and CX also had higher ($P < 0.05$) flavor ratings than the LT (Table 2). Consumers rated the LT and SS similar ($P > 0.05$) in flavor intensity, with the DP receiving the lowest ($P < 0.05$) scores for flavor. Quality grade effects and muscle type × quality grade interactive effects for flavor were nearly significant ($P = 0.0632$ and 0.0889, respectively). Carmack et al. (1995) ranked 12 muscles for flavor intensity and found the SS have the least beef flavor intensity.

Consumer Panel Ratings for Overall Like

For overall like, the IF was rated the highest, followed by the TB, and both muscles were rated higher ($P < 0.05$) than the LT. The SV and CX were rated as being similar ($P > 0.05$) to the LT for overall like, whereas the SS was rated lower ($P < 0.05$) than the LT (Table 2). The DP rated the lowest ($P < 0.05$) for overall like. The muscle × quality grade interaction ($P < 0.007$) indicated that Choice SS and SV rated higher for overall like than Select SS and SV, respectively; however, Select DP was rated higher than Choice DP. Quality grade did not ($P > 0.05$) have an effect on the overall like ratings of the IF, TB, CX, and LT. There is a broad range in tenderness, juiciness, and flavor profiles across the different muscles, explaining why some muscles were liked and others were disliked. Goodson et al. (2002) did not find a quality grade effect for overall like for clod (TB) steaks for consumers in Chicago and Philadelphia, which agrees with these findings. Our findings also are in agreement with those of Lorenzen et al. (1999), who did not find an effect of quality grade on overall like of top loin steaks within high-Select and low-Choice quality grades.

Consumer Panel Ratings for Price

A summary for prices assigned by consumers is listed in Table 2. Consumers were willing to pay the most ($P < 0.05$) for IF steaks, followed by the TB ($5.68 and $5.15, respectively). Consumers assigned similar ($P > 0.05$) prices for the LT, SV, and CX ($4.57, $4.78, and $4.75/0.45 kg, respectively); a lower ($P < 0.05$) price for the SS ($4.01/0.45 kg); and a much lower ($P < 0.05$) price for the DP ($2.86/0.45 kg). Consumers generally ranked muscles on price similar to their rankings on overall like. Moreover, there were no quality grade ($P = 0.140$) or quality grade × muscle type interactive ($P = 0.136$) effects for consumer ratings of price.

Palatability Traits and Overall Like Correlations

Correlations between palatability traits and overall like are shown in Table 3. Across all muscles, tenderness, juiciness, and flavor were all highly correlated (r = 0.76 or higher) with one another. Additionally, all traits were highly correlated with each other. These results indicate that all palatability traits are important to consumers, and they are all interrelated with one another when overall like is evaluated. However, tenderness was the trait that had the highest correlation (r = 0.84) with overall like, which might indicate that consumers find tenderness the most important palatability trait. Neely et al. (1998) found a similar correlation for tenderness and overall like. Results of the present study agree with those of Shackelford et al. (2001), who found similar correlations for juiciness; however, they noted a higher correlation for flavor than was observed in the current study.

Table 3. Correlation coefficients among consumer palatability ratings for all muscles from the beef chuck[a]

Trait	Tenderness	Juiciness	Flavor	Price
Overall like	0.84	0.77	0.76	0.78
Tenderness		0.73	0.63	0.73
Juiciness			0.72	0.70
Flavor				0.68

[a]All coefficients were significant ($P < 0.001$).

Tenderness, juiciness, and flavor were all highly correlated with price (Table 3). Price and overall like were highly correlated (r = 0.78). However, the correlation among palatability traits and price was noticeably lower than those among overall like and palatability traits. This would indicate that consumers were influenced by some factors other than tenderness, juiciness, and flavor when they assigned prices for the samples.

Implications

The complexus, serratus ventralis, triceps brachii, and infraspinatus were acceptable to consumers as steaks, and rated equal or superior to longissimus thoracis steaks. By using these muscles as steaks instead of roasts, value could be added to the beef carcass. The added value could result in more total dollars being paid for beef and could lead to greater profits for beef retailers, processors, and producers.

Literature Cited

Brooks, J. C., J. B. Belew, D. B. Griffen, B. L. Gwartney, D. S. Hale, W. R. Henning, D. D. Johnson, J. B. Morgan, F. C. Parrish Jr., J. O. Reagan, and J. W. Savell. 2000. National Beef Tenderness Survey-1998. J. Anim. Sci. 78:1852–1860.

Carmack, C. F., C. L. Kastner, M. E. Dikeman, J. R. Schwenke, R. Garcia, and C. M. Zepeda. 1995. Sensory evaluation of beef-flavor-intensity, tenderness, and juiciness among major muscles. Meat Sci. 39:143–147.

Bureau of Labor Statistics. 2002. Consumer Price Index. U.S. Bureau of Labor Statistics. Washington, DC.

Goodson, K. J., W. W. Morgan, J. O. Reagan, B. L. Gwartney, S. M. Courington, J. W. Wise, and J. W. Savell. 2002. Beef Customer Satisfaction: Factors affecting consumer evaluations of clod steaks. J. Anim. Sci. 80:401–408.

Johnson, R. C., C. M. Chen, T. S. Muller, W. J. Costello, J. R. Romans, and K. W. Jones. 1988. Characterization of the muscles within the beef forequarter. J. Food Sci. 53:1247–1250.

Lorenzen, C. L., T. R. Neely, R. K. Miller, J. D. Tatum, J. W. Wise, J. F. Taylor, M. J. Buyck, J. O. Reagan, and J. W. Savell. 1999. Beef Customer Satisfaction: Cooking method and degree of doneness effects on the top loin steak. J. Anim. Sci. 77:637–644.

Medina, S., and R. W. Ward. 1999. A multinomial logic model of retail outlet selection for beef. Florida Ag. Exp. Jour. Series R-19990605.

Menkaus, D. J., D. P. M. Colin, G. D. Whipple, and R. A. Field. 1993. The effects of perceived product attributes on the perception of beef. Agribusiness 9:57–63.

Morgan, J. B., J. W. Savell, D. S. Hale, R. K. Miller, D. B. Griffin, H. R. Cross, and S. D. Shackelford. 1991. National Beef Tenderness Survey. J. Anim. Sci. 69:3274–3283.

NCBA. 2000. Muscle profiling. National Cattlemen's Beef Association, Denver, CO.

Neely, T. R., C. L. Lorenzen, R. K. Miller, J. D. Tatum, J. W. Wise, J. F. Taylor, M. J. Buyck, J. O. Reagan, and J. W. Savell. 1998. Beef Customer Satisfaction: Role of cut USDA quality grade, and city on in-home consumer ratings. J. Anim. Sci. 76:1027–1032.

Paterson, B. C., and F. C. Parrish, Jr. 1986. A sensory panel and chemical analysis of certain beef chuck muscles. J. Food Sci. 51:876–879.

Purcell, W. D. 1993. Consumers' Buying Behavior for Beef: Implications of Price and Product Attributes. Research Bulletin 1–93. Research Institute on Livestock Pricing Agricultural and Applied Economics, Virginia Tech., Blacksburg, VA.

Ramsbottom, J. M., E. J. Strandine, and C. H. Koonz. 1945. Comparative tenderness of representative beef muscles. Food Res. 10:497–509.

Shackelford, S. D., T. L. Wheeler, M. K. Meade, J. O. Reagan, B. L. Byrnes, and M. Koohmaraie. 2001. Consumer impressions of Tender Select beef. J. Anim. Sci. 79:2605–2614.

Smith, G. C., Z. L. Carpenter, H. R. Cross, C. E. Murphey, H. C. Abraham, J. W. Savell, G. W. Davis, B. W. Berry, and F. C. Parrish, Jr. 1984. Relationship of USDA marbling groups to palatability of cooked beef. J. Food Qual. 7:289–308.