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Evaluating consumer acceptability and willingness to pay for various beef chuck muscles[1]

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ABSTRACT: In-home consumer steak evaluations, followed by centralized laboratory-setting auctions, were used to determine consumer (n = 74 consumers) acceptability and willingness to pay for various beef chuck muscles. The infraspinatus (IF), serratus ventralis (SV), supraspinatus (SS), and triceps brachii (TB) from the beef chuck were evaluated against LM steaks from the rib to determine price and trait differentials. Muscles from USDA Choice, boneless, boxed-beef subprimals were aged 14 d, frozen, and cut into 2.5-cm-thick steaks. Consumers received two steaks from each muscle for in-home evaluations of uncooked steak appearance and cooked steak palatability. After in-home evaluation of steaks, consumers participated in a random nth price auction session to determine willingness to pay for those steaks. Muscles differed ($P < 0.05$) for overall like of appearance, like of size, like of shape, and like of leanness; LM generally rated the highest. Steaks from the LM rated highest ($P < 0.05$) for overall like, and steaks from the SS and SV were lowest ($P < 0.05$) for overall like. Juiciness and beef flavor intensity scores were highest ($P < 0.05$) for steaks from the LM and IF, whereas SS steaks received the lowest ($P < 0.05$) juiciness scores, and SS and SV steaks were rated lowest ($P < 0.05$) for beef flavor intensity. Average auction price differentials differed ($P < 0.05$) from the LM, and were $–0.71, $–0.79, $–1.75, and $–2.44/0.45 kg for the TB, IF, SS, and SV, respectively. Average appearance trait differentials and average palatability trait differentials were correlated significantly with average price differentials. Results indicate the IF and TB were acceptable to consumers as steaks but only at prices lower than the LM.

Key Words: Beef, Chuck Muscles, Consumers, Economics, Palatability, Steak Appearance

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Introduction

In the last decade, demand for the more tender middle cuts of beef (rib and loin) has increased, and demand for the tougher end cuts of beef (chuck and round) has decreased. This increased demand for the beef rib and loin is shown by an increasing retail price spread between middle meats and end cuts (BLS, 2002). Additionally, as demand for middle cuts increased, the average retail beef prices remained relatively unchanged during the 1990s because of the lower demand for chuck and round cuts. Traditionally, chuck has been merchandised in the form of low-priced roasts. According to Purcell (1993), families with more than one wage earner have decreased their consumption of the beef chuck roast, probably because of the time required to prepare a roast. In addition, highly educated and higher-income consumers feel that they do not know how to prepare a chuck roast (Purcell, 1993).

Several studies have documented palatability traits of the major muscles of beef chuck with the use of trained sensory panels and objective tenderness measurements (Ramsbottom et al., 1945; Johnson et al., 1988; NCBA, 2000). Results of these studies have shown that some of the major muscles, such as the infraspinatus (**IF**), serratus ventralis (**SV**), and triceps brachii (**TB**), might be suitable for use as steaks instead of roasts. Several studies have examined consumer willingness to pay for various attributes of beef. Boleman et al. (1997), Mintert et al. (2000), and Lusk et al. (2001) reported that consumers were willing to pay a premium for tender steaks. Moreover, Umberger et al. (2000) reported that consumers were willing to pay a premium for the type of beef flavor they preferred. With the recent emphasis by the beef industry to utilize the undervalued muscles from beef chuck, we attempted to deter-

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mine consumers' willingness to pay for steaks from chuck muscles.

Materials and Methods

Muscles

Ten each of the IF, SV, supraspinatus (**SS**), and TB from beef chuck and LM from the beef rib were obtained from USDA Choice boxed-beef subprimals (the IF and TB from Institutional Meat Purchasing Specifications [**IMPS**] cut #114C, the SV from IMPS #116A, the SS from IMPS #116B, and the LM from IMPS #112A). The IF, SV, SS, and TB were selected because they are large muscles from the beef chuck previously identified as being acceptable as steaks to consumers (Kukowski et al., 2004). Muscles were aged at 2°C for 14 d from box date and then frozen. Frozen muscles were cut perpendicular to the grain of the muscle fiber into 2.5-cm-thick steaks on a band saw and vacuum-packaged with two steaks of the same muscle per package. All external and seam fat was trimmed to <3 mm. One package of each muscle type was labeled with a random number, and each steak package was labeled with a color, indicating the type of steak (all steaks of a given type received the same color). Steaks were placed in a box identified by a number from 1 to 100 to identify the consumer for later analysis. Steak, muscle name, and weight were not indicated on any of the packaging. Steaks (10 per household) were held at –26°C until given to the consumer. The steak shape and size for an individual IF steak was oval and approximately 140 g; an individual SV steak was long and narrow and approximately 160 g; an individual TB steak was oval and approximately 225 g; and an individual LM steak was oval and 170 g.

Consumer Panel

Consumers representing 100 households from Brookings, South Dakota, and surrounding communities received the boxes of steaks on a first-come, first-served basis as they shopped at the South Dakota State University Meat Laboratory. Participants were informed that by accepting the steaks, they were required to participate in the auction portion of the study. At no time were consumers informed about the name, weight, or type of steaks they received. Participants were instructed on how to fill out the ballot when they received their steaks. Participants were not given cooking instructions. Participants also completed a demographic questionnaire. In-home evaluations of overall like of uncooked steak appearance, like of steak shape, like of steak size, and like of steak leanness were rated using 10-point hedonic scales, with anchored endpoints (1 = dislike extremely to 10 = like extremely). Additionally, cookery method of the steaks (charcoal grill, gas grill, electric grill, broil, panfry, roast, bake, other) also was indicated by the participants. Estimated degree of doneness for each steak (rare, medium rare, medium, medium well, and well done) was reported by the consumer. Overall like, tenderness, juiciness, and flavor intensity of cooked steaks were rated by consumers using 10-point anchored endpoint scales (1 = dislike extremely, extremely tough, extremely dry, or extremely bland to 10 = like extremely, extremely tender, extremely juicy, or extremely intense). Consumers had a minimum of 2 wk and a maximum of 9 wk between receiving the steaks and participating in the auction. This time allowed consumers to evaluate all steaks before participation in the auction. Consumers retained all in-home sensory data throughout the study to allow for review of their ratings and comments for each muscle before the start of the auction. Consumers representing 74 households of the initial 100 households returned ballots and participated in the auction portion of the study.

Random nth Price Auctions

After evaluating all steaks, consumers participated in a random nth price auction (Lusk et al., 2004) to determine their willingness to pay for the steaks. Seven auctions were held at seven different times; consumers participated in only one auction. Consumers were familiarized with the auction procedure by participating in a practice auction using candy bars. Consumers then participated in the actual steak auction. Participants were given $15 before bidding to use to purchase 0.45-kg packages of the same types of steak used in the in-home portion of the study. Retail packages of each steak type were on display before and during the auction to assist participants in remembering and evaluating the steak types. Participants were given the option to leave at any time during the auction and keep the $15, but no consumer left the auction early. Consumers were given instructions for steak auctions verbally and in written format. Current retail prices in Brookings, South Dakota, for various beef cuts were given to the participants to use as a reference when making their bids; however, consumers were not given prices of the cuts they had consumed.

Sealed bids were submitted by each auction participant on a price/0.45 kg basis for each type of steak for each of five auction rounds. A random number (n) was drawn after the bids were collected for each round of the auction, which represented the nth highest price bid in that round of the auction. The number n was set from two to the total number of participants in the auction if the number of participants was less than eight or from two to the total number of participants divided by two if there were more than eight participants. The number n was used to determine the number of winners (n – 1) and the price (the price bid by the nth bidder) for each round. For example, if the number four was drawn, the panelists who submitted the three highest bids were winners of that round and would pay the fourth highest price bid for steaks. Winning price

and winning bidders were reported for each round for all participants to review before submitting bids for the next round. After completion of the final round, a number between one and five was drawn to determine which of the five auctions rounds was to be considered binding. The round that was considered binding was the round that determined the winning bidders and winning prices for a particular auction session. Participants were required to purchase the steaks they had won in the binding auction round at the sale price.

Statistical Analyses

Consumer ratings for appearance and palatability of the two packaged steaks of each type that were evaluated in-home were averaged for each consumer household. Frequencies for consumer demographic data, consumer comments, cooking method, and perceived degree of doneness were calculated using the frequency procedure of SAS (SAS Inst., Inc., Cary, NC). Consumer appearance and palatability ratings were analyzed using the GLM procedure of SAS as a completely randomized design. Muscle was the main effect, and consumer household was the experimental unit. Least squares means were calculated for all appearance and palatability traits, and means were separated using a pair-wise *t*-test (PDIFF option of SAS). Average appearance and palatability trait differentials were calculated by subtracting the average consumer household rating for each appearance and palatability trait of steaks from each chuck muscle from the average consumer ratings for the LM. For example, if a consumer household rated an IF steak 5 and 7 for tenderness, and they rated the LM steak 6 and 8, the average rating for the IF would be 6 and that for the LM would be 7. The rating of 6 was then subtracted from 7 to get the differential rating of one. Similarly, average price differentials were calculated by subtracting the average bid price for each consumer from all rounds for each steak type from the average bid price for that consumer for the LM. The means procedure of SAS was used to calculate mean differentials, and the PROBT option was used to test whether the correlations were significantly different from zero. Correlations were obtained for the appearance, palatability, and price differentials using the CORR procedure of SAS.

Results and Discussion

Consumer Panelist Demographics

Demographic data for this study are summarized in Table 1. Households typically contained young people (40% from ages 20 to 29 yr) from two-person households (40%) who worked full time (62%) and were moderate to frequent beef consumers (beef served three to five times per week by 69% of the consumers). The age demographic exceeds 100% because the total number of people in the household was reported by age. Demographics were not correlated to ratings of appearance ($P = 0.55$), palatability traits ($P = 0.01$), or willingness to pay for steaks ($P = 0.66$; results not shown).

Table 1. Frequencies of demographic information (n = 74 consumers)

Variables	Frequency, %
Total number of people in household	
1	17
2	44
3	16
4	19
≥5	4
Age of people in household[a]	
<20 yr	40
20 to 29 yr	40
30 to 39 yr	28
40 to 49 yr	20
50 to 59 yr	17
≥60 yr	17
Annual income per household	
<$20,000	21
$20,000 to $29,000	15
$30,000 to $39,000	18
$40,000 to $49,000	14
$50,000 to $59,000	10
≥$60,000	23
Work status of head of household	
Not employed	3
Part time	3
Full time	62
Student	18
Retired	15
Number of times beef served per week	
<3 times	17
3 to 5 times	69
≥5 times	13

[a]All people in the household were reported; therefore, a number >100 is possible.

Consumer Panel Ratings for Like of Uncooked Steak Appearance

Ratings for overall like of appearance, like of shape, like of size, and like of leanness for the uncooked steaks are summarized in Table 2. Ratings for overall like of appearance, like of shape, like of size, and like of leanness varied ($P < 0.05$) across all muscle types. Steaks from the LM, TB, and SS were rated higher ($P < 0.05$) for overall like of appearance; the IF and the SV received the lowest ($P < 0.05$) overall like of appearance scores. Ratings for like of shape were highest for steaks from the LM and TB and lowest ($P < 0.05$) for steaks from the SV. Consumers rated LM steaks highest ($P < 0.05$) for like of size, followed by TB steaks, which were rated higher ($P < 0.05$) for like of size than steaks from the IF, SS, and SV; steaks from the SV received the lowest ($P < 0.05$) like of size scores. Steaks from the LM were rated highest ($P < 0.05$) for like of leanness, and steaks from the TB, SS, and IF received higher ($P < 0.05$) like of leanness scores than steaks from the SV.

Table 2. Least squares means for consumer overall like of appearance, like of shape, like of size, and like of leanness ratings of beef steaks from various muscles (n = 74)

Muscle	Overall like of appearance[a]	Like of shape[a]	Like of size[a]	Like of leanness[a]
Serratus ventralis	6.09[b]	5.38[b]	6.47[b]	6.43[b]
Infraspinatus	7.22[c]	7.70[c]	7.17[c]	7.11[c]
Supraspinatus	7.75[d]	7.74[cd]	6.85[bc]	7.31[c]
Triceps brachii	8.03[d]	8.14[de]	7.87[d]	7.54[c]
Longissimus	8.11[d]	8.23[e]	7.95[e]	8.14[d]
SEM	0.15	0.15	0.17	0.16

[a]1 = dislike extremely to 10 = like extremely.
[b,c,d,e]Within a column, least squares means that do not have a common superscript letter differ, $P < 0.05$.

Consumers consistently rated the LM desirable for appearance traits, suggesting that even though consumers were unaware they were evaluating a ribeye steak, they had an expectation of steak appearance. The SV, which is long and narrow, might have been unfamiliar as a steak shape to most consumers compared with the more typical round or oval shape of the LM, causing the SV to be consistently rated low for appearance traits. Steak weight did not seem to affect ratings of appearance, including ratings for size.

Consumer Panel Ratings for Palatability Traits

Results of ratings for overall like, tenderness, juiciness, and flavor intensity are summarized in Table 3. Consumers rated LM steaks highest ($P < 0.05$), and IF and TB steaks higher ($P < 0.05$) than SS and SV steaks, for overall like. In-home consumer tenderness ratings of the LM and IF were higher ($P < 0.05$) than those from the TB, SS, and SV; and TB steaks were rated higher ($P < 0.05$) than steaks from the SS and SV. Steaks from the LM and IF were rated the highest ($P < 0.05$) for juiciness, and steaks from the SV and TB were rated juicier ($P < 0.05$) than steaks from the SS. Steaks from the LM were rated highest ($P < 0.05$) for flavor intensity, and TB steaks were rated higher ($P < 0.05$) for flavor intensity than steaks from the SV and SS. McKeith et al. (1985) reported that a trained sensory panel rated the IF similar to the LM for tenderness, juiciness, and flavor, which agrees with the in-home sensory findings reported in this study. Johnson et al. (1988) found the SV to be one of the more tender muscles in the beef chuck when evaluated with Warner-Bratzler shear force. Kukowski et al. (2004) reported central location consumer panel ratings for the IF, TB, SS, and SV and found that consumers rated all of the listed muscles as acceptable as steaks. In the current study, however, consumer households rated SV steaks as the least acceptable. There might be differences in how consumers rate samples when comparing in-home taste panels vs. central location taste panels. It is possible that the SV is a muscle that is susceptible to becoming dry or tough because of overcooking. Muscle profiling data (NCBA, 2000) indicated that the SV was moderately tough when prepared with dry cookery, and the most common method of preparation for this study was grilling.

Willingness to Pay

Average price differentials/0.45 kg of chuck muscle steaks, with the LM as a reference, are shown in Table 4. Average price differentials for the TB, IF, SS, and SV were negative and different ($P < 0.05$) from zero, indicating that the amounts consumers were willing to pay for steaks from chuck muscles were less ($P < 0.05$) than they were willing to pay for LM steaks. Steaks from the TB and IF had the smallest and similar average price differentials (–$0.71 and –$0.79/0.45 kg, respectively). The average price differential for SS steaks

Table 3. Least squares means for consumer overall like, tenderness, juiciness, and flavor intensity ratings of beef steaks from various muscles (n = 74)

Muscle	Overall like[a]	Tenderness[a]	Juiciness[a]	Flavor intensity[a]
Serratus ventralis	6.02[b]	5.58[b]	6.83[c]	6.67[b]
Supraspinatus	6.28[b]	5.64[b]	6.32[b]	6.35[b]
Triceps brachii	7.12[c]	6.59[c]	6.81[c]	7.18[c]
Infraspinatus	7.47[c]	7.61[d]	7.47[d]	7.53[cd]
Longissimus	8.11[d]	7.95[d]	7.73[d]	7.69[d]
SEM	0.17	0.18	0.17	0.16

[a]1 = dislike extremely, extremely tough, extremely dry, extremely bland to 10 = like extremely, extremely tender, extremely juicy, extremely intense.
[b,c,d]Within a column, least squares means that do not have a common superscript letter differ, $P < 0.05$.

Table 4. Average price differentials of beef steaks from various muscles compared with the longissimus (n = 74)

Muscle	Average price differential, $/0.45 kg[a]
Triceps brachii	$–0.71[b]
Infraspinatus	$–0.79[b]
Supraspinatus	$–1.75[c]
Serratus ventralis	$–2.44[d]

[a]All price differentials were significantly different from zero.
[b,c,d]Within a column, means that do not have a common superscript letter differ, $P < 0.05$.

(–$1.75/0.45 kg) was greater than the average price differential for TB and IF steaks. Steaks from the SV had the largest average price differential among steaks presented for auction. Average price differentials revealed the minimum discount consumers required to induce them to purchase the IF, TB, SS and SV, relative to the LM; that is, if the SV were priced $2.44/0.45 kg less than LM steaks, consumers would be willing to buy SV at the same rate they would buy LM. Palatability ratings of the muscles in this study revealed that consumers preferred the LM over the other muscles in the study; therefore, it is not surprising that all of the average price differentials for the chuck muscles were negative. For example, the difference between the LM and the other muscles for overall like was –0.64, –0.99, –1.83, –2.09 for the IF, TB, SS, and SV, respectively (results not shown).

Many researchers have investigated willingness to pay for beef steaks; however, most studies have focused on common steaks such as ribeye, top loin, and/or top sirloin steaks (Boleman et al., 1997; Umberger et al., 2000). Most willingness-to-pay research indicates that consumers are willing to pay more for tender steaks or steaks that meet their expectations for flavor (Umberger et al., 2000). The current research found similar results across muscles; the steaks consumers rated highest for overall like had the lowest marginal price differences compared with LM steaks.

Correlations among Average Price Differentials and Average Appearance Differentials

Correlations among average appearance differentials and average price differentials are presented in Table 5. Like of shape and like of leanness were the only average appearance trait differentials that were correlated ($P < 0.05$) to average price differentials for the IF (r = 0.28 and 0.26, respectively). All appearance trait differentials were correlated ($P < 0.05$) to average price differentials for the TB, and the highest correlation was between average price differential and average like of lean differentials. Overall like of appearance was the only average appearance differential that was correlated ($P < 0.05$) to average price differential for the SS (r = 0.29). All appearance trait differentials were correlated to average price differentials for the SV, with like of size highly correlated to average price differential (r = 0.46). These results suggest that appearance traits for the SS were not very important contributors to price. The lack of importance of appearance traits for the SS might be due to the very acceptable ratings given to the SS for appearance traits vs. the less desirable palatability ratings given to the SS. When consumers were bidding on SS steaks, the less desirable palatability traits likely were more important than appearance.

Correlations among Average Price Differentials and Average Palatability Differentials

All palatability differentials were correlated ($P < 0.05$) to average price differentials for the IF; however, overall like had the highest correlation with average price differentials (Table 6). Overall like, tenderness, and juiciness were all significantly correlated to average price differentials for the TB; however, juiciness had the highest correlation coefficient (r = 0.45). Overall like, tenderness, and juiciness were correlated ($P < 0.05$) to average price differentials for SS steaks, and tenderness had the highest correlation with SS price differentials. All palatability traits were correlated ($P < 0.05$) to average price differentials for the SV, and overall like had the highest correlation coefficient. Palatability trait differentials were more highly correlated to average price differentials than were average appearance trait differentials, suggesting that consumers were more concerned about palatability of chuck steaks than appearance.

Implications

The triceps brachii and infraspinatus were acceptable to consumers as steaks but at prices lower than the

Table 5. Correlations among average appearance differentials and average price differentials of beef steaks from various chuck muscles

Muscle	Overall like of appearance	Like of shape	Like of size	Like of leanness
Infraspinatus	0.11	0.28*	0.17	0.26*
Triceps brachii	0.27*	0.34*	0.25*	0.52*
Supraspinatus	0.29*	0.12	0.19	0.17
Serratus ventralis	0.30*	0.28*	0.46*	0.41*

*Correlation coefficients, $P < 0.05$.

Table 6. Correlations among average palatability differentials and average price differentials of beef steaks from various chuck muscles

Muscle	Overall like	Tenderness	Juiciness	Flavor
Infraspinatus	0.39*	0.34*	0.38*	0.38*
Triceps brachii	0.33*	0.40*	0.45*	0.14
Supraspinatus	0.35*	0.41*	0.32*	0.19
Serratus ventralis	0.44*	0.28*	0.42*	0.35*

*Correlation coefficients, $P < 0.05$.

longissimus muscle. By using these muscles as steaks instead of roasts, greater value could be added to the beef carcass. The added value would result in more total dollars being paid for beef, and it could lead to greater profits for beef retailers, processors, and producers.

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