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Evaluating the Point of Separation, During Carcass Fabrication, Between the Beef Wholesale Rib and the Beef Wholesale Chuck

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ABSTRACT: This study determined whether there is a logical point of value change, related to either tenderness or consumer acceptance, at which to separate the beef carcass within the rib/chuck region. Rib/chuck rolls (RCR); (n = 30) consisting of the ribeye roll and chuck eye roll subprimals (2nd through 12th rib locations) were cut into 22 steaks each (two steaks per rib location), and Warner-Bratzler shear force and consumer purchase preference were evaluated for steaks at each rib location. Steaks from different locations of the RCR were composed of differing proportions of several muscles: longissimus muscle (LM), spinalis dorsi and multifidus dorsi (SM), and complexus (CO). The LM (4th to 12th rib) contained three tenderness regions: 7th through 12th rib, 5th and 6th ribs, and 4th rib regions (lowest, intermediate, and highest shear force values, respectively; $P < 0.01$). Shear force differed ($P < 0.05$) among rib locations for the SM (2nd to 9th rib), but no logical pattern was evident. The CO (2nd to 7th rib) was more tender toward the anterior end ($P < 0.05$). The region of the RCR represented by the 4th through 6th rib locations had steaks with higher weighted-average shear force (average shear force of each steak, weighted for surface area of each muscle) values than the remainder of the RCR ($P < 0.05$). Animal-to-animal variation in shear force was 36% greater than rib-to-rib variation in shear force; thus, statistically significant differences in tenderness among rib locations may be undetectable by consumers. Steaks (n = 330) were offered for sale at a retail supermarket and case time was monitored on each steak to determine consumer purchase preference. Steaks from the 2nd through 4th rib locations required more time to sell ($P < 0.01$) than steaks from the 5th through 12th rib locations. Two alternative locations for the rib/chuck separation point could be between the 6th and 7th ribs, yielding a ribeye subprimal useful in marketing a "premium quality" product, or between the 4th and 5th ribs, which would yield four more 2.5-cm ribeye steaks per carcass.

Key Words: Beef, Carcass Composition, Consumer, Ribs, Tenderness

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Introduction

From 1988 to 1997, demand among U.S. consumers increased for the most tender cuts of beef and decreased for the least tender cuts of beef. This is evidenced by a dramatically increasing retail price spread between middle meats (loin and rib) and end meats (round and chuck) during that time period (AMI, 1999). Despite increased demand for middle meats, the average retail price of beef did not increase during the 1990s because of lower demand for end meats. Because of this large and growing price difference between middle meats and end meats, it is important to analyze critically the point of separation, during carcass fabrication, between the wholesale rib and wholesale chuck. Traditionally, in the United States, the wholesale rib is separated from the wholesale chuck between the 5th and 6th rib bones. Therefore, the ribeye roll is fabricated from the 6th through 12th rib section of the carcass and the chuck eye roll is fabricated from the 1st through 5th rib section of the carcass. There seems to be no logical explanation for separating the rib from the chuck at this point other than tradition. The same muscles are present in the ribeye roll and the chuck eye roll. A separation point between two wholesale cuts of meat should be made at some point where there is a marked real value difference. Therefore, this study determined whether there is a logical point of value change, related to either tenderness or consumer acceptance, at which to separate the beef carcass within the rib/chuck region.

Materials and Methods

Thirty Limousin-Angus and Angus steers were slaughtered in four groups at the South Dakota State

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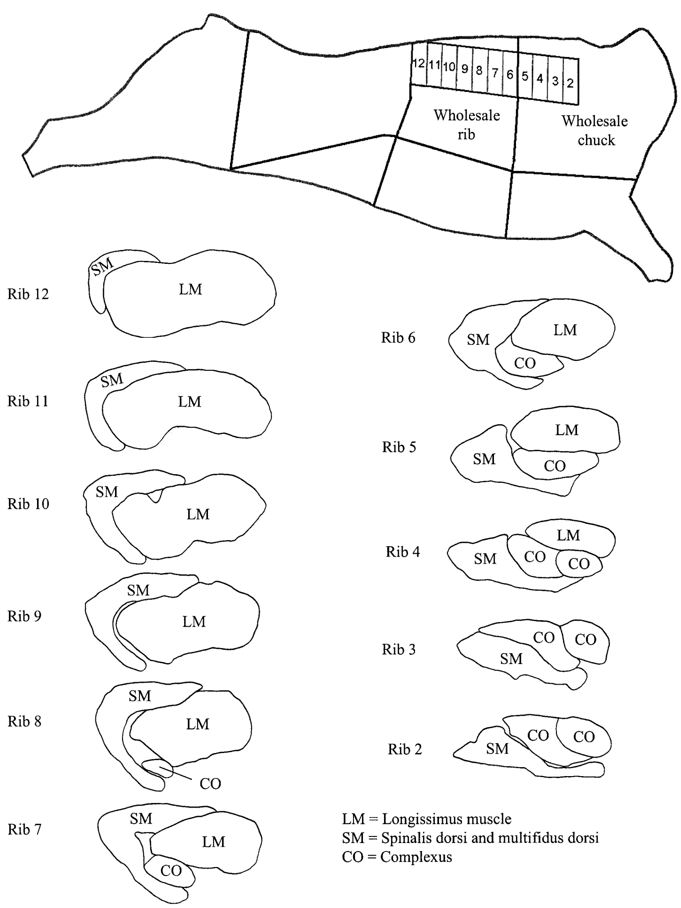

Figure 1. Schematic of ribeye/chuck eye roll (RCR) location and consecutive steaks from each rib location represented in the RCR. Relative size of muscles present at each rib location is shown.

University Meat Laboratory. After a 48-h chill (1°C), carcasses were ribbed between the 12th and 13th ribs and experienced evaluators determined USDA yield grade and quality grade from the right side of each carcass. At 48 h postmortem, a bone-in section consisting of the 2nd though 12th ribs, termed the ribeye/chuck roll (**RCR**), was removed from the left side of each carcass. Figure 1 shows the anatomical location of the RCR. The cap muscles (latissimus dorsi, rhomboideus, and trapezius) were removed and RCR were vacuum-packaged and aged for eight additional days at 2°C. At 10 d postmortem, the position of each rib bone was marked by the insertion of a knife at the anterior edge of each intercostal gap and rib bones were removed. Two boneless steaks were sliced by hand from each rib section (max. 2.54 cm thick); one steak from each rib section was retail-wrapped for consumer purchase preference evaluation and the other steak from each rib section was vacuum-packaged and frozen for shear force evaluation at a later time. The surface areas of each muscle from a steak from each rib location of five randomly chosen RCR were traced on acetate paper. The muscles present in each steak location are shown in Figure 1.

Consumer Purchase Preference Determination

Each steak designated for consumer purchase preference evaluation was trimmed of excess peripheral fat and placed with a soakerpad on a black 2S retail Styrofoam display tray and retail-wrapped with oxygen-permeable film. The kernal fat (seam fat between longissimus and spinalis dorsi muscles) was removed if it exceeded 1.27 cm in width. Steaks were taken in two groups to a supermarket in Sioux Falls, South Dakota and a label containing the company name, retail cut name (ribeye steak), wholesale cut name (beef rib), use-by date, net weight, unit price, and total price was placed in the upper left hand corner of the package. Additionally, a small orange label with the word "Ribeye" was placed on each package in the upper right-hand corner. Finally, a small identification number was inconspicuously placed on the label identifying the animal and rib location origin of each steak. All steaks were labeled and priced identically as "ribeye steaks" regardless of whether they originated from the wholesale rib or the wholesale chuck. A sign was posted on the wall above the retail case that stated "Temporary Price Cut, Ribeye Steak, $3.99 lb., limit 2 per customer." Steaks from two animals (22 steaks) were randomized and placed in the retail display case at the beginning of the evaluation period. After 11 steaks were purchased, 11 more steaks from a single animal were randomized and put into the case. If at any time four steaks from any one rib location were in the case at the same time, the first steak entering the case of the four was removed to avoid a situation of any single rib location dominating the offering. No steaks were removed because of discoloration because the study concluded prior to any visible surface metmyoglobin formation; steaks were only removed from the case to maintain a selection balance among steaks from various rib locations. If a steak was removed, the time at which it was removed was recorded. Steaks were monitored at the meat case and, as steaks were purchased, identification numbers and purchase times were recorded. The difference between purchase time (or removal time) and time when each steak was first put into the case was considered the "retail display time" for each individual steak. The purpose of calculating "retail display time" was not to estimate realistic expected industry retail display times, but rather to determine only whether consumers visually preferred steaks from certain rib locations over steaks from other rib locations. Order of purchase was also determined for each steak by ranking the steaks within each animal according to retail display time. If more than one steak from the same animal was purchased at the same time by the same customer, the order of purchase for those steaks was considered identical and was calculated by averaging the rankings for those steaks.

Shear Force Determination

Steaks were thawed at 2°C for 24 h and then broiled on Farberware Open Hearth electric broilers (Farber-

Table 1. Means, standard deviations, and minimum and maximum values for live weight and carcass traits

Item	Mean	SD	Miniumum	Maxiumum
Live weight, kg	561	14	539	581
Carcass wt, kg	346	10	330	363
Adjusted fat thickness, cm	1.22	0.36	0.64	2.29
Longissimus muscle area, cm^2	80.6	7.7	69.0	98.7
Actual kidney, pelvic, and heart fat, %	3.5	0.7	2.4	5.1
USDA yield grade	3.3	0.7	2.4	4.9
Overall maturity[a]	154	11	130	180
Marbling score[b]	413	57	330	570

[a]100 = A^{00}, 200 = B^{00}, etc.
[b]300 = $slight^{00}$, 400 = $small^{00}$, etc.

ware, Bronx, NY). Steaks were turned every 4 min until an internal temperature of 71°C was reached. Steaks were allowed to cool to room temperature (≈22°C) and as many 1.27-cm-diameter core samples as possible (with a maximum of six) were taken parallel to the muscle fiber orientation from each muscle in each steak. A single peak shear force value was obtained for each core using a Warner-Bratzler shear machine and the shear force values were averaged for each animal for each muscle for each rib location.

Statistical Analysis

Warner-Bratzler shear force, case time, and buy rank were analyzed using SAS (SAS Inst. Inc., Cary, NC) as a two-way ANOVA design with animal and anatomical location (i.e., rib bone number) as main effects. Least squares means were calculated for each anatomical location and separated using pairwise *t*-tests.

Results and Discussion

Mean carcass trait values (Table 1) were generally representative of the population sampled in the 1995 NBQA (Boleman et al., 1998). However, less variation existed among carcasses in this study than in the 1995 NBQA. Therefore, this group of carcasses was an excellent test sample because they were a) representative of the industry average and b) consistent.

Retail steak weights and the percentage of steaks requiring kernal fat trimming are shown in Table 2. Retail steak weights tended to increase from the 2nd rib location to the 10th rib location and decline slightly from the 10th rib location to the 12th rib location. About three-quarters of the steaks from the 7th and 8th rib locations required kernal fat trimming (kernal fat exceeded 1.27 cm wide), whereas 1 of 15 to none of the steaks from the other rib locations required kernal fat trimming.

Consumer Purchase Preference

The purpose of the consumer purchase preference evaluation was to determine whether or not consumer willingness to purchase a ribeye steak differs among rib locations in order to aid in determining a logical point of separation between the wholesale rib and the wholesale chuck. The results of the consumer purchase preference evaluation are shown in Figures 2 and 3. Retail display times (Figure 2) were substantially shorter than what would typically be expected in the retail industry. Short retail display times were desired by the researchers in order to facilitate data collection, and probably resulted from the following: 1) a substantial price discount was placed on the ribeye steaks, 2) a large sign was used to advertise the temporary price cut, and 3) the study was conducted on Fridays and Saturdays, the two busiest grocery shopping days of the week, in late May and early June, the beginning of grilling season. Because of the price discount, some of the steaks were probably purchased by consumers who would not typically buy ribeye steaks; however, we feel that the data are an accurate estimate of consumer purchase preference because these consumers still visually determined which packages they preferred. It was not the intent of the study to estimate typical industry retail display times, but rather the intent was to see whether consumers visually prefer steaks from different locations of the RCR. Lack of large differences in display time would suggest that consumers are fairly impartial in visual selection of steaks from the 12th

Table 2. Retail steak weight and percentage of steaks requiring kernel fat trimming by rib location

Rib location	Retail steak weight, kg (n = 15)	% Requiring kernel fat trimming (n = 15)
12	0.31	0.0
11	0.33	0.0
10	0.34	0.0
9	0.34	6.7
8	0.31	73.5
7	0.29	80.0
6	0.29	6.7
5	0.27	6.7
4	0.20	0.0
3	0.16	6.7
2	0.17	6.7

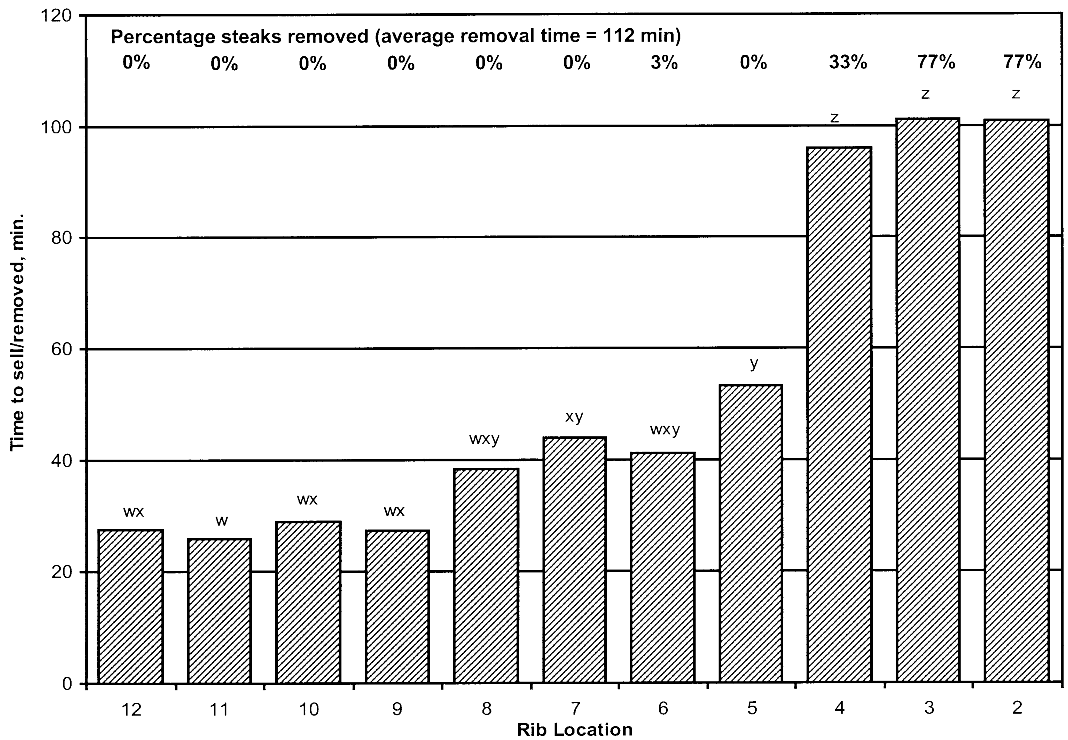

Figure 2. Average time steaks from each rib location spent in the retail case before being purchased or removed and percentage of steaks removed for each rib location. [w,x,y,z]Bars lacking a common letter differ ($P < 0.05$).

through 5th rib locations. Steaks from the 4th through 2nd rib locations required more time to sell and there was a greater number of "removals" among steaks from these locations than for steaks from the 12th through 5th rib locations. The only statistically significant difference in display time between two adjacent rib loca-

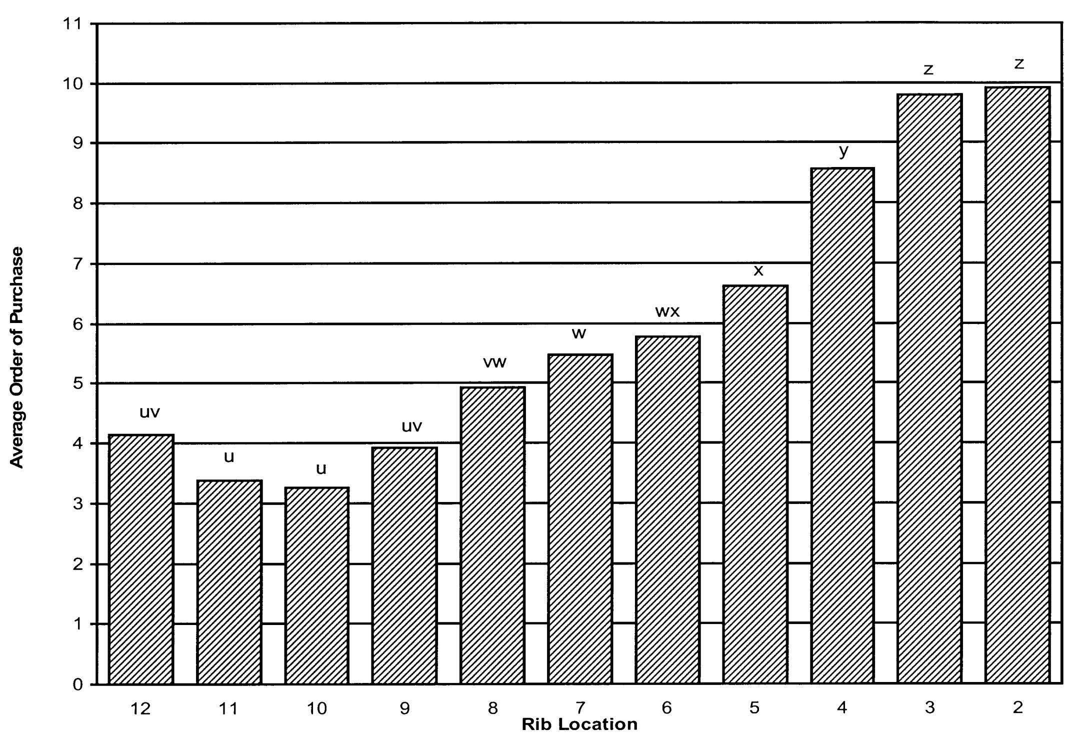

Figure 3. Average order of purchase of steaks by rib location quantified by retail display time. [u,v,w,x,y,z]Bars lacking a common letter differ ($P < 0.05$).

Table 3. Muscle[a] surface area and shear force values by rib location

Rib Location	Area, cm^2 LM	SM	CO	Shear force, kg LM	SM	CO	Weighted average[b]
12	92	14	—	3.49^{x}	—	—	3.47^{yz}
11	86	23	—	3.58^{x}	—	—	3.53^{yz}
10	79	29	—	3.44^{x}	—	—	3.42^{yz}
9	72	34	—	3.45^{x}	3.23^{yz}	—	3.38^{yz}
8	57	34	3	3.41^{x}	3.31^{wxyz}	—	3.39^{yz}
7	45	35	8	3.56^{x}	3.25^{xyz}	4.06^{x}	3.48^{yz}
6	43	33	13	4.00^{y}	3.47^{w}	4.02^{xy}	3.81^{x}
5	37	27	18	4.08^{y}	3.44^{wx}	3.98^{xy}	3.84^{x}
4	19	26	23	4.57^{z}	3.41^{wxy}	3.81^{yz}	3.79^{x}
3	—	25	32	—	3.16^{z}	3.86^{xyz}	3.56^{yz}
2	—	23	35	—	3.47^{w}	3.65^{z}	3.57^{y}

[a]LM = longissimus muscle, SM = spinalis dorsi and multifidus dorsi, CO = complexus.

b Weighted average shear force is the average shear force for a given steak weighted according to individual muscle proportions. If muscle area was too small at a certain rib location to obtain accurate shear force cores, an average shear force value for that muscle averaged across all other rib locations was used to calculate weighted average shear force.

[w,x,y,z] Least squares means within a column lacking a common superscript letter differ ($P < 0.05$).

tions was between the 4th and 5th ribs. To examine further the consumer purchase data, we also calculated the average order of purchase for steaks from each rib location (Figure 3). Consumers clearly showed a visual preference for steaks from the posterior rib locations compared to the anterior rib locations, with the greatest numeric difference in average order of purchase occurring between the 5th and 4th rib locations. Consumers visually preferred steaks from 12th through 5th rib locations over steaks from 4th through 2nd rib locations. The lack of consumer willingness to purchase steaks from rib locations 4 through 2 is an important factor to consider in deciding upon the point of separation between the wholesale rib and wholesale chuck.

Shear Force

Shear force was evaluated to determine whether differences in tenderness from end-to-end of the RCR should dictate the point of separation between the wholesale rib and wholesale chuck. Table 3 shows that there was indeed end-to-end shear force variation within the RCR. Steaks from different locations in the RCR are composed of differing proportions of three muscles: complexus **(CO)**, spinalis dorsi and multifidus dorsi **(SM)**, and longissimus muscle **(LM)** (Figure 1).

The LM originated at the 4th rib location and continued through the 12th rib location. There was a tenderness gradient observed in the LM, which allowed for identification of three tenderness regions (Table 3). The 7th through 12th rib locations represented the most tender (lowest shear force) region, the 5th and 6th rib region was intermediate in tenderness, and the 4th rib location was the least tender (highest shear force). Ramsbottom et al. (1945) reported the LM to be more tender at the posterior and middle portions than at the anterior end, which is in agreement with our findings. In the present study, there was no difference in shear force in steaks from the 7th through the 12th rib locations, which is in agreement with Satorius and Child (1938), who also reported no significant variation in shear force of the LM from the 7th to the 12th rib locations. However, other studies have reported LM tenderness differences within the 7th through 12th rib section; for example, Christians et al. (1961) reported the LM to be more tender at the 12th rib than at the 8th or 9th ribs, whereas Henrickson and Mjoseth (1964) reported the opposite, greater tenderness at the 7th and 9th ribs than at the 11th and 13th ribs.

The SM was present at every rib location; however, it was too narrow to obtain accurate shear force data at rib locations 10 through 12. Significant differences ($P < 0.05$) in shear force were observed among rib locations for the SM, but no logical pattern was evident (Table 3).

The CO originated in the 8th rib section and continued though the 2nd rib location, but it was too small to obtain accurate shear force data at the 8th rib location. The CO at rib location 2 was more tender than the CO at rib locations 5 through 7 (Table 3). Overall, the CO was more tender toward the anterior end of the RCR.

Table 3 also contains the weighted-average shear force of each steak from each rib location of the RCR. The region of the RCR represented by the 4th through 6th rib locations had steaks with higher weighted-average shear force values compared to the rest of the RCR, primarily a result of higher LM shear force values in this region.

Figure 4 shows weighted average shear force for each rib location along with the amount of animal-to-animal variation within each rib location. As evidenced by the amount of overlap among the bars shown in Figure 4, there was more tenderness variation among animals than there was among rib locations. Overall, as calculated from ANOVA main effects mean squares, animal-

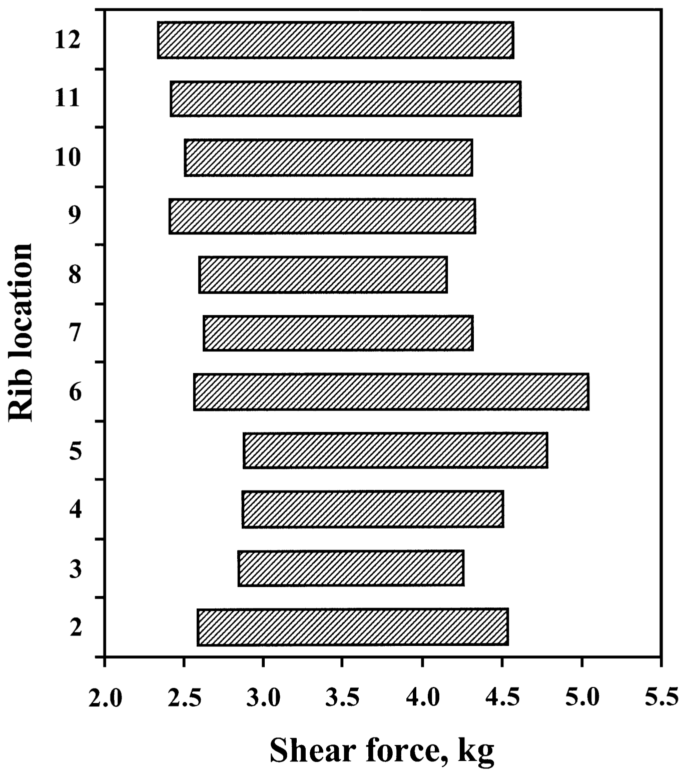

Figure 4. Weighted average shear force of steaks from each rib location. Each bar represents the shear force mean ± two standard deviations. Therefore, the length of each bar represents animal-to-animal variation within each rib location.

to-animal variation in shear force was 36% greater than rib-to-rib variation in shear force. Animal-to-animal tenderness variation in the U.S. marketplace would probably be even greater than that reported in this study because the animals used in this study were relatively uniform in breed type, sex, and carcass traits (Table 1). These results indicate that, although statistically significant differences in tenderness existed among RCR steaks from different rib locations, these differences would probably not be detected by consumers because they fall within the normal amount of tenderness variation that occurs within ribeye steaks in the marketplace.

Economic Impact

From the results of the present study, based on analyses of shear force data and consideration of consumer purchase preference information, the point of separation (during fabrication of the carcass) between the wholesale rib and the wholesale chuck could be changed from the present 5th/6th rib juncture. Depending on marketing objectives, there seem to be two logical locations, neither of which is the current 5th/6th rib location, to separate the wholesale rib from the wholesale chuck.

The first possibility (Option A) is to move the point of separation of the wholesale rib from the wholesale chuck to between the 6th and 7th ribs. The 7th rib through 12th rib section was more tender, based on shear force, than the 4th through 6th rib section. Option A may be useful in the marketing of a "Premium Quality" or "Guaranteed Tender" product. If the point of separation of the rib from the chuck at the 6th and 7th rib locations were used, there would be four fewer 2.5-cm steaks to be sold from the wholesale rib; however, the remaining steaks in the rib would be of greater tenderness and could potentially be sold for a premium.

The second possibility (Option B) is to move the rib/chuck breakpoint anterior to a point between the 4th and 5th ribs. There was no significant ($P < 0.05$) difference in shear force among rib locations 4 through 6 and the 6th rib location is currently being successfully marketed as ribeye steaks. Furthermore, animal-to-animal variation in shear force exceeded rib-to-rib variation in shear force. These findings suggest that steaks from as far anterior as the 2nd rib location could be used as ribeye steaks without substantially compromising tenderness. However, consumer purchase preference evaluation revealed that there was a significant increase in display time (i.e. decreased consumer willingness to purchase) for steaks from the 2nd through 4th rib locations, compared to the 5th through 12th rib locations. These findings would suggest that the point of separation between the rib and chuck could be moved to a point between the 4th and 5th ribs and still retain similar tenderness and consumer purchase preference compared to current ribeye steaks.

Moving the rib/chuck point of separation one rib anterior would allow the industry to sell four more 2.5-cm ribeye steaks per carcass. The 5th rib location steaks in this study had an average weight of 0.27 kg, which when multiplied by four steaks per carcass would yield 1.08 additional kg of ribeye steaks per carcass. Assuming the retail price difference between ribeye steaks and chuck eye steaks is $7.00/kg, this would result in a potential total of $7.56 per carcass in added value at the retail level. According to AMI (1999), 47% of the average beef retail price is the equivalent farm value; therefore, $7.57 additional retail value should translate into $3.55/animal added value for the beef producer.

Implications

Based on analyses of shear force and consideration of consumer purchase preference information, there seems to be no logical reason for separating the beef wholesale rib from the beef wholesale chuck between the 5th and 6th ribs other than tradition. Two alternative locations for the point of separation between the wholesale rib and wholesale chuck have been proposed. Option A is to move the rib/chuck point of separation to between the 6th and 7th ribs, thereby excluding a less tender steak from the ribeye roll. Option B is to move the rib/chuck point of separation to a point between the 4th and 5th ribs, which would result in four additional 2.5-cm ribeye steaks per beef carcass with minimal effect on beef consumer satisfaction.

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