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BEEF REPORT

CHARACTERIZATION OF THE MUSCLES WITHIN THE BEEF FOREQUARTER

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Summary

Thirty-four muscles/muscle groups, each greater than .1 kg, were dissected from 16 forequarters to establish a data base of individual muscle yields, palatability profiles and chemical composition. Carcass data from the 16 steers revealed the following averages: carcass weight - 288.4 kg, yield grade - 3.2, and quality grade - low choice. Individual muscle yields, tenderness profiles and chemical analyses indicated that the muscles within the forequarter are extremely variable. However, several of the larger muscles within the forequarter possess tenderness profiles comparable to the longissimus dorsi, the major muscle within rib steaks. This study suggests that maximum utilization of the beef forequarter may best be achieved when individual muscles are fabricated and marketed according to their size and tenderness potential.

(Key Words: Beef, Forequarter, Muscle, Tenderness, Composition.)

Introduction

The beef forequarter represents approximately 52% of the total carcass weight and is composed of the primal chuck and rib and the rough brisket, plate and shank. Traditionally, an inequivalency in the market value exists between the fore- and hindquarter at both the packer and retail level, primarily due to the lower value of the beef chuck. Merchantability of the beef forequarter, especially the chuck, has been depressed due to the high degree of variability in (1) the cutout yield of the forequarter and (2) the palatability characteristics of the numerous muscles within the forequarter.

Considerable time, effort and research has been expended in developing new approaches to merchandising chuck meat. Increased efficiencies in fabrication and handling of the beef chuck have been obtained by subdividing the chuck and removing all bone and a large percentage of the subcutaneous and intermuscular fat before the chuck enters the marketing channels. Attempts to improve the retail acceptability of chuck meat (i.e., grinding, tenderizing, restructuring, precooking, etc.) have had nearly immeasurable impact on increasing the value of the chuck and forequarter.

Numerous studies have characterized the muscles that traditionally account for a majority of the beef carcass value due to their size and palatability profiles. However, since these muscles are primarily located in the hindquarter, minimal baseline information is available on the majority of the muscles within the forequarter. This lack of information has placed a severe limitation on the development of fabrication and processing techniques which would maximize the economic potential of the beef forequarter. Thus, this study was undertaken to characterize each muscle within the beef forequarter in terms of physical and chemical characteristics.

Materials and Methods

Sixteen Angus steers of similar genetic and feedlot background (14-16 months of age) were slaughtered at the South Dakota State University Meat Laboratory. After a 48-hour chill, grade data were collected (USDA, 1975). The forequarter (FQ) from one side of each carcass was broken into a rib/plate portion (R/P) and an arm chuck portion with the brisket attached (AC/B). The forequarters were broken in to only these two subportions to minimize the extent to which the individual muscles were subdivided. These carcass portions, excluding the shank,

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were dissected into 34 individual muscles/muscle groups, fat and bone. Individual weights were taken of all components of the carcass portions. The shank muscles were removed and included in miscellaneous trim. Table 1 lists the 34 muscles/muscle groups which were dissected from each forequarter, the wholesale cut in which these muscles are found and the three-letter code used to identify each muscle.

TABLE 1. MUSCLES OF THE BEEF FOREQUARTER

Muscle	Wholesale cut[a]	Muscle code
Anoconeus	C	ACN
Biceps brachii	C	BPB
Brachialis	C	BCL
Brachiocephalicus	C	BCC
Complexus	C,R	CPX
Coracobrachialis	C	CBC
Cutaneus omo-brachialis	C,P,R	COB
Deep pectoral	B,C,P	DPT
Deltoideus	C	DEL
Infraspinatus	C	INF
Latissimus dorsi	C,P,R	LTD
Longissimus costarum	C,R	LGC
Longissimus dorsi	C,R	LGD
Multifidus dorsi	C,R	MFD
Neck muscles[b]	C	NKM
Obliquus abdominis externus	P,R	OAE
Rectus thoracis	B,C	RTR
Rhomboideus	C,R	RBD
Scalenus ventralis	C	SCV
Serratus dorsalis	C,R	SRD
Serratus ventralis	C,P,R	SRV
Spinalis dorsi	C,R	SLD
Splenius	C	SLN
Sternocephalicus	C	SCP
Subscapularis	C	SCL
Superficial pectoral	B,C	SFP
Supraspinatus	C	SPN
Tensor fasciae antibrachii	C	TFA
Teres major	C	TRM
Teres minor	C	TRN
Trapezius	C,R	TRA
Triceps brachii, lateral head	C	TBT
Triceps brachii, long head	C	TBL
Triceps brachii, medial head	C	TBM

[a] B = brisket, C = chuck, P = plate and R = rib.
[b] Neck muscles consist of several muscles immediately adjacent to the cervical vertebra.

Following muscle removal, identification and weighing, heavy epimysium connective tissue (silver membrane) was removed from each muscle and relative thickness was measured with a micrometer. The remaining muscle tissue was used for objective tenderness evaluation (Warner-Bratzler shear) and chemical analyses (moisture, fat, protein, ash and collagen). The shank muscles were not included in the chemical characterization analyses.

Results and Discussion

The means and ranges of the carcass characteristics for the 16 Angus steers used in this study are given in table 2. The average carcass in this study was a USDA low choice, YG 3.2, steer carcass weighing 288.4 kg.

TABLE 2. MEANS AND RANGES OF CARCASS CHARACTERISTICS

Trait	N	Mean	Minimum	Maximum	SE[a]
Carcass weight, kg	16	288.4	234.1	316.6	5.06
Fat thickness. cm	16	1.17	.81	2.04	.08
Rib eye area, sq cm	16	65.8	58.3	73.5	1.12
Kidney, heart and pelvic fat, %	16	2.2	1.5	3.0	.09
Yield grade[b]	16	3.2	2.6	4.3	.12
Marbling score[b]	16	Small 20	Slight 60	Modest 30	11

[a] Standard error of the mean.
[b] Based on descriptions included in USDA (1975) beef grade standards.

The percentage contribution made by each individual muscle to the lean portion of the FQ, R/P and AC/B are presented in table 3. Due to the fabrication techniques utilized in this study, the contribution that each muscle makes to the lean portion of the various subportions of the beef forequarter (i.e. rib/plate and arm chuck/brisket) is not representative of traditional concepts. Therefore, caution is advised when interpreting the data.

The serratus ventralis (SRV) was the largest muscle in the forequarter (table 3) and thus contributed the greatest percentage to both the forequarter and the arm chuck/brisket lean. If the brisket had been removed from the arm chuck, it may be postulated that the SRV would have contributed an even greater percentage of the arm chuck lean since a large portion of the deep pectoral (DPT) and superficial pectoral (SFP) would not have been included. The triceps brachii complex (TBL, TBT and TBM), when pooled together, account for the greatest percentage of lean within the arm chuck/brisket (11.6%).

The largest muscle by weight of the rib/plate portion was OAE, which is the outer surface muscle of the plate. However, because of the location and lack of thickness of this muscle, OAE does not make an economically important contribution to this portion of the carcass. Thus, LGD and the smaller muscles generally marketed with it (i.e., SLD, LGC, MFD and CPX) account for the greatest percentage of the economic return to the rib/plate portion.

TABLE 3. RANK OF BEEF FOREQUARTER MUSCLES BY COMPOSITION OF THE LEAN WITHIN THE FOREQUARTER, RIB/PLATE AND ARM CHUCK/BRISKET[a]

	Forequarter			Rib/Plate			Arm Chuck/Brisket		
Rank	Muscle	%	SE[b]	Muscle	%	SE[b]	Muscle	%	SE[b]
1	SRV	10.3	.12	OAE	23.9	.57	SRV	11.0	.15
2	DPT	9.2	.12	LGD	22.8	.59	DPT	10.3	.16
3	TBL	7.0	.07	LTD	12.4	.31	TBL	9.4	.09
4	LGD	6.6	.13	SLD	8.8	.25	CPX	7.3	.13
5	TRA	6.4	.24	SRV	8.0	.20	TRA	7.0	.31
6	OAE	6.1	.13	COB	6.3	.16	NKM	6.7	.17
7	CPX	5.7	.09	DPT	5.9	.22	INF	6.4	.09
8	LTD	5.0	.06	TRA	4.3	.24	SFP	5.3	.08
9	NKM	5.0	.14	LGC	2.5	.11	SPN	4.2	.04
10	INF	4.8	.07	MFD	1.7	.09	RBD	3.4	.09
11	SLD	4.0	.05	RBD	1.7	.14	BCC	3.1	.23
12	SFP	3.9	.05	CPX	.9	.07	SCL	2.9	.04
13	SPN	3.1	.04	SRD	.8	.04	SCP	2.8	.24
14	RBD	3.0	.04				LTD	2.5	.07
15	BCC	2.3	.16				SLN	2.5	.07
16	SCP	2.1	.18				SLD	2.3	.06
17	SCL	2.1	.03				TBT	1.9	.04
18	COB	1.9	.07				BPB	1.8	.03
19	SLN	1.8	.05				BCL	1.3	.02
20	TBT	1.4	.03				TRM	1.3	.02
21	BPB	1.3	.02				LGD	1.0	.07
22	TRM	1.0	.01				DEL	.9	.03
23	BCL	.9	.02				SCV	.7	.04
24	LGC	.9	.03				TRN	.6	.02
25	DEL	.7	.02				COB	.5	.05
26	MFD	.7	.03				TFA	.5	.01
27	SCV	.5	.03				CBC	.4	.01
28	TRN	.5	.01				MFD	.4	.04
29	TFA	.4	.01				RTR	.4	.01
30	CBC	.3	.01				ACN	.3	.01
31	RTR	.3	.01				LGC	.3	.01
32	SRD	.3	.01				SRD	.3	.01
33	ACN	.2	.01				TBM	.3	.01
34	TBM	.2	.01						

[a] See table 1 for a listing of the muscle codes.
[b] Standard error of the mean.

Warner-Bratzler shear values for those muscles which were large enough for analysis are given in table 4. The four most tender muscles (LGD, SLD, INF and SRV) account for just over 25% of the lean within the forequarter. Currently, LGD and SLD are the primary muscle components of subprimal rib cuts, i.e., rib eye rolls and oven-prepared ribs. The other two muscles, INF and SRV, represent 17.4% of the arm chuck/brisket lean. The remainder of the muscles have less desirable shear values. Alteration of the tenderness profile of these muscles by mechanical or enzymatic tenderization is highly recommended.

TABLE 4. RANK OF FOREQUARTER MUSCLES BY WARNER-BRATZLER SHEAR FORCE[a]

Rank	Muscle	WBS	SE[b]	Rank	Muscle	WBS	SE[b]
1	LGD	2.18	.23	13	TBT	3.32	.19
2	SLD	2.21	.09	14	LTD	3.39	.11
3	INF	2.23	.11	15	SLN	3.46	.15
4	SRV	2.28	.11	16	NKM	3.61	.15
5	TBL	2.63	.09	17	BCL	3.62	.11
6	CPX	2.79	.12	18	DEL	3.63	.12
7	SPN	2.83	.17	19	TRA	3.74	.21
8	TRM	2.88	.09	20	DPT	3.89	.19
9	SFP	2.88	.21	21	SCP	4.05	.25
10	BPB	3.04	.10	22	COB	4.14	.18
11	SCL	3.21	.17	23	BCC	4.40	.30
12	RBD	3.23	.26				

[a] See table 1 for a listing of the muscle codes. Warner-Bratzler shear force (kg/1.3 cm core) was determined on muscle samples following removal of heavy epimysium connective tissue.
[b] Standard error of the mean.

Table 5 presents the rank of muscles based on epimysium connective tissue thickness, moisture and fat percentage and total collagen content. The epimysium connective tissue ranged in thickness from 16-.62 mm (SRD and INF, respectively). The thickness of the epimysium appears to be related to the size of the muscle which it encases and attaches to the skeleton or other muscles, and to the function of the muscle in relation to movement of the animal. The variation in fat content of the muscles indicates that some muscles possess inherent characteristics which would make them very desirable for low-fat products (i.e., Triceps brachii complex and SPN). Correlation coefficients indicated total collagen content accounted for less than 10% of the variation in Warner-Bratzler shear force and was therefore a poor predictor of tenderness.

In conclusion, results of the physical and chemical characterization analyses of the individual muscles within the forequarter indicate that some muscles would have a potentially greater economic value if they were separated and used independently. Due to their physical and chemical characteristics, SRV and INF from the beef chuck are suitable for steak production as individual muscles. Similarly, the triceps brachii complex (TBL, TBT and TBM) and SPN would be desirable material for roast production.

TABLE 5. RANK OF BEEF FOREQUARTER MUSCLES BY EPIMYSIUM CONNECTIVE TISSUE THICKNESS, PERCENTAGE MOISTURE AND FAT AND TOTAL COLLAGEN[a]

	Epimysium		Moisture		Fat		Total collagen[b]	
Rank	Muscle	mm	Muscle	%	Muscle	%	Muscle	mg/g
1	SRD	.16	SLN	73.0	TBL	3.1	LGD	2.81
2	ACN	.19	TBT	72.4	SLN	3.3	TRM	3.15
3	COB	.20	BPB	72.3	TBT	3.6	TBL	3.78
4	TBM	.23	BCL	72.3	TFA	3.6	SRV	4.14
5	BCC	.26	TRN	72.3	BCL	3.9	SCL	4.54
6	SFP	.26	SPN	72.0	SPN	3.9	SRD	4.58
7	SLN	.26	TBL	71.9	BPB	4.0	RTR	4.68
8	TFA	.26	TFA	71.8	TRN	4.1	SLD	4.74
9	RBD	.27	TRM	71.4	SCL	4.5	TFA	5.33
10	SCV	.28	BCC	71.2	TRM	4.6	SCV	5.45
11	TRA	.28	SCL	70.9	BCC	5.1	CPX	5.57
12	LTD	.29	DEL	70.6	DEL	5.1	BCL	5.68
13	RTR	.30	CBC	70.6	CBC	5.5	INF	5.81
14	SCP	.30	CPX	70.4	LTD	6.0	SLN	5.88
15	TBT	.31	NKM	70.3	LGD	6.2	TBT	5.88
16	CBC	.34	DPT	70.1	DPT	6.3	DPT	5.95
17	DPT	.35	INF	69.6	NKM	6.6	BPB	6.37
18	LGC	.35	LTD	69.6	CPX	6.7	SPN	6.39
19	SPN	.35	TBM	69.6	INF	7.3	TBM	6.40
20	DEL	.36	RTR	69.1	RTR	7.5	OAE	6.53
21	BPB	.37	LGD	68.8	TBM	7.5	LGC	6.64
22	CPX	.40	LGC	68.8	RBD	8.1	LTD	7.02
23	MFD	.40	ACN	68.7	LGC	8.6	DEL	7.03
24	TRM	.41	SCP	68.6	ACN	9.0	ACN	7.28
25	TRN	.41	RBD	68.2	SCP	9.3	RBD	7.75
26	BCL	.42	SCV	68.0	SCV	9.4	TRN	8.69
27	NKM	.43	SLD	67.0	SLD	10.7	CBC	8.71
28	SRV	.45	SRV	66.7	TRA	11.1	SCP	9.19
29	LGD	.48	SFP	66.6	SRV	11.3	NKM	9.27
30	OAE	.50	TRA	66.4	SFP	12.1	BCC	9.53
31	SCL	.54	SRD	64.2	SRD	13.0	TRA	9.76
32	SLD	.55	OAE	62.6	COB	15.9	MFD	9.86
33	TBL	.61	MFD	61.8	OAE	16.5	SPF	11.05
34	INF	.62	COB	60.0	MFD	16.8	COB	14.37

[a] See table 1 for a listing of the muscle codes.
[b] Collagen content of the muscle tissue excluding heavy epimysium tissue, mg collagen/g of muscle tissue.