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Significant ($P < .05$) yield grade effects were seldom linear, reflecting inconsistent trends as yield grade increased or decreased.

Moisture (4 out of 5 muscles), L^* value (7 out of 7 muscles), a^* value (8 out of 8 muscles), b^* value (6 out of 6 muscles), and expressible moisture (5 out of 6 muscles) increased with an increase in weight of carcass. How-

ever, pH (4 out of 4 muscles), fat (4 out of 5 muscles), and emulsion capacity (5 out of 5 muscles) decreased with an increase in weight of carcass. Total collagen showed no effect across all 39 muscles due to weight.

These data indicate a vast amount of variation in physical and chemical properties among muscles of the beef chuck and round. Knowledge of these

properties now allows individual muscles to be identified and utilized for production of value-added products.

¹Drew D. Von Seggern, graduate student. Chris Calkins, Professor, Animal Science, Lincoln. This project was funded by beef producers through their \$1/head checkoff and produced for the Cattleman's Beef Board and State Beef Councils.

Fiber Type Composition of the Beef Chuck and Round

Kevin Kirchofer
Chris Calkins¹

There is wide variability in fiber types of beef chuck muscles. This would be expected to create different processing characteristics which influence optimal muscle use in value-added products.

Summary

The fiber type composition of 38 muscles of the beef chuck and round was studied to facilitate optimal muscle use in value-added products. Select grade chucks and rounds (n=4 each) were used. Muscles containing greater than 40% β -red fiber numbers were classified as red; greater than 40% α -white were classified as white. All others were classified as intermediate. Nine of 12 round muscles were white, while chuck muscles were equally dispersed between red (10 of 26), intermediate (9 of 26), and white (7 of 26), indicating variation among muscles of the chuck, which may create differences in processing characteristics.

Introduction

There is a relationship between ultimate meat quality and muscle fiber type composition. Muscles with increased α white (α W) fibers have

more connective tissue, less intramuscular fat, and are less tender than muscles with more β -red (β R) fibers. Not only do individual muscles differ in fiber type composition, but muscle fiber types within a specific muscle may be affected by breed, sex, time on feed and maturity.

Muscle fiber types have been reported for many of the larger muscles of the beef carcass. Little attention has been given to the smaller muscles that comprise the chuck and the round. With many of these muscles going to further processing, there is a need for a fiber type profile of these muscles. The objective of this study was to characterize the histochemical muscle fiber type of 23 muscles of the beef round and 26 muscles of the beef chuck to help in the application of muscles into value-added products through the use of further processing.

Procedure

Select-grade chucks and rounds (n=4 each) were chosen representing two weight ranges (550-650 lbs, and 800-900 lbs) and two yield grades (yield grade 1 and 3). Twelve muscles of the beef round and 26 muscles of the beef chuck were fabricated and sampled. Muscle samples were frozen in liquid nitrogen within nine days post mortem and subsequently stored at -112°F until histochemical analysis was performed.

One cubic centimeter of frozen tissue was mounted on a cryostat chuck

in such a manner to set muscle fibers perpendicular to the cutting blade. The mounted cubes were allowed to equilibrate to -4.0°F before being sliced to a thickness of 12 μ m on a cryostat. The slices were mounted on slides and allowed to equilibrate to room temperature before being stained.

Muscle sections were stained according to a simultaneous staining technique, which included a stain for succinic dehydrogenase activity and a stain for acid-active adenosine triphosphatase activity after acid incubation. Cover slips were permanently mounted over the stained tissue to enable fiber classification.

Fibers were classified on the basis of stain reactions: β -red fibers stained dark brown, α -red fibers were clear in the middle and surrounded by a blue ring, and α -white fibers were clear. Fiber numbers were calculated by examining a minimum of 500 muscle fibers from muscle bundles containing at least 50 fibers per bundle. Muscle fiber percentage was calculated by counting the total number of each fiber type, dividing by the total number of fibers counted, and multiplying the quotient by 100:

$$\text{Fiber Number (\%)} = \frac{\text{Fiber Number (\beta-red, } \alpha\text{-red, or } \alpha\text{-white)}}{\text{Total Fiber Number}} * 100.$$

Muscles were classified as red, intermediate, or white on the basis of the average muscle fiber number (%). Muscles were classified as red if they

(Continued on next page)

Table 1. Muscle fiber type characteristics of red^a muscles.

MUSCLE	Trait	β-Red		α-Red		α-White	
		Mean	(S.E. ^b)	Mean	(S.E. ^b)	Mean	(S.E. ^b)
Trapezius	Number (%)	62.56	(3.72)	21.48	(3.08)	15.96	(2.97)
	Diameter (μm)	34.98	(0.77)	40.92	(0.91)	46.53	(0.89)
	Area (μm ²)	991.81	(42.70)	1364.04	(62.87)	1751.72	(65.06)
	Percent Area	51.94	(1.26)	24.84	(1.36)	23.23	(1.47)
<i>Brachialis</i>	Number (%)	61.93	(2.14)	28.98	(1.98)	9.10	(1.45)
	Diameter (μm)	33.78	(0.80)	38.72	(0.95)	47.83	(0.79)
	Area (μm ²)	935.37	(44.52)	1228.69	(57.93)	1826.27	(61.16)
	Percent Area	51.43	(0.89)	32.42	(1.06)	16.14	(1.38)
<i>Multifidous & spinalis dorsi</i>	Number (%)	60.19	(1.90)	22.12	(2.94)	17.69	(1.69)
	Diameter (μm)	30.57	(0.65)	38.04	(0.91)	48.41	(0.89)
	Area (μm ²)	751.88	(31.51)	1191.37	(54.92)	1875.69	(67.84)
	Percent Area	43.06	(0.91)	24.91	(1.15)	32.03	(1.34)
<i>Biceps brachii</i>	Number (%)	58.71	(1.98)	22.73	(1.06)	18.56	(3.02)
	Diameter (μm)	35.97	(0.78)	38.24	(0.78)	49.40	(0.77)
	Area (μm ²)	1044.19	(45.61)	1173.31	(48.21)	1944.99	(60.08)
	Percent Area	48.72	(0.95)	21.70	(1.17)	29.58	(1.29)
<i>Intertransversales</i>	Number (%)	52.51	(5.84)	25.16	(3.44)	22.33	(4.61)
	Diameter (μm)	33.49	(0.88)	42.56	(0.80)	43.28	(0.81)
	Area (μm ²)	935.11	(48.73)	1503.14	(54.59)	1537.00	(57.12)
	Percent Area	40.09	(1.03)	29.48	(1.26)	30.43	(1.29)
<i>Complexus</i>	Number (%)	51.59	(5.95)	22.93	(1.34)	25.48	(5.18)
	Diameter (μm)	31.01	(0.69)	41.65	(1.02)	47.54	(0.91)
	Area (μm ²)	774.79	(34.31)	1424.84	(68.80)	1811.30	(68.68)
	Percent Area	33.92	(1.02)	27.31	(1.01)	38.77	(1.26)
<i>Levatores costarum</i>	Number (%)	46.87	(2.65)	26.23	(4.21)	26.90	(1.94)
	Diameter (μm)	37.36	(0.92)	53.67	(1.11)	55.44	(1.10)
	Area (μm ²)	1141.65	(56.51)	2387.26	(97.39)	2520.63	(98.61)
	Percent Area	29.34	(0.85)	33.45	(1.06)	37.21	(1.25)
<i>Infraspinatus</i>	Number (%)	46.64	(3.04)	28.51	(2.72)	24.85	(3.55)
	Diameter (μm)	36.69	(0.84)	44.31	(0.91)	52.89	(0.98)
	Area (μm ²)	1143.30	(51.67)	1623.98	(67.05)	2289.55	(86.77)
	Percent Area	32.86	(0.64)	29.82	(1.05)	37.32	(1.24)
<i>Brachiocephalicus omoctransversarius</i>	Number (%)	42.22	(1.24)	28.32	(1.01)	29.46	(1.21)
	Diameter (μm)	34.85	(0.76)	44.90	(0.95)	54.25	(0.87)
	Area (μm ²)	987.40	(42.04)	1621.15	(67.56)	2353.15	(76.67)
	Percent Area	26.49	(0.77)	29.44	(1.18)	44.07	(1.24)
<i>Longissimus capitus et Atlantis</i>	Number (%)	40.99	(4.20)	27.87	(1.30)	31.14	(4.16)
	Diameter (μm)	34.35	(0.78)	40.99	(0.92)	49.11	(0.95)
	Area (μm ²)	954.54	(43.40)	1357.75	(61.23)	1939.91	(74.79)
	Percent Area	28.59	(0.92)	28.20	(1.16)	43.21	(1.18)

^aMuscles containing greater than 40% β - Red fiber numbers were classified as red.

^bStandard error of the fiber type traits by muscle.

had more than 40% β-red fibers. White muscles had more than 40% α-white fibers, and all other muscles were classified as intermediate muscles.

Fiber diameters were found by capturing photomicrographs with a black and white, monochrome camera mounted on a light microscope. A minimum of 50 diameters of each fiber type (β-red, α-red, and α-white) were measured with the help of computer software. Muscle fiber area was calculated from the fiber diameters: $A = \pi (\text{diameter}/2)^2$. Percent area was calculated for each fiber type by first multiplying the average fiber type number by the average of the fiber area for a spe-

cific muscle, next, dividing by the total area, and finally, multiplying the quotient by 100:

$$\%A = (\text{Average Fiber Area} * \text{Average Fiber Number} (\%) / \text{Total Area}) * 100.$$

The analysis of variance included muscle and carcass weight group as main effects. Significant ($P < .05$) interactions were separated using contrasts to test for linearity.

Results

Tests of the interaction of carcass weight group and muscle and tests of

the effect of carcass weight group on muscle fiber type characteristics were not significant for any of the characteristics studied ($P > .05$). The effect of muscle on fiber type characteristics was always significant ($P < .002$). Data were pooled by muscle, and means were calculated for fiber number (%), diameter, area and percentage area. Means are presented by muscle classification in Tables 1, 2, and 3.

Based on the literature, we anticipated fiber-type characteristics would be significantly influenced by carcass weight, although this is indirectly associated with an animal's ultimate size and age at slaughter. Because animals used

Table 2. Muscle fiber type characteristics of intermediate^a muscles.

MUSCLE	Trait	β-Red		α-Red		α-White	
		Mean	(S.E. ^b)	Mean	(S.E. ^b)	Mean	(S.E. ^b)
<i>Vastus lateralis</i>	Number (%)	22.18	(4.53)	37.95	(7.99)	39.87	(5.02)
	Diameter (μm)	36.49	(0.94)	46.84	(1.03)	56.21	(1.11)
	Area (μm ²)	1086.48	(55.51)	1770.50	(78.74)	2529.68	(98.97)
	Percent Area	12.42	(0.95)	35.24	(1.19)	52.34	(1.16)
<i>Subscapularis</i>	Number (%)	39.48	(3.30)	33.05	(3.70)	27.47	(1.16)
	Diameter (μm)	33.69	(0.75)	39.41	(0.84)	53.80	(0.97)
	Area (μm ²)	916.25	(40.29)	1252.60	(53.29)	2311.24	(83.46)
	Percent Area	25.63	(1.09)	29.23	(1.17)	45.14	(1.16)
<i>Triceps brachii</i>	Number (%)	33.50	(1.48)	31.89	(2.10)	34.61	(2.09)
	Diameter (μm)	33.80	(0.85)	43.07	(0.93)	52.50	(1.20)
	Area (μm ²)	939.40	(45.85)	1497.66	(63.53)	2233.62	(99.82)
	Percent Area	20.14	(0.50)	31.17	(0.99)	48.69	(1.15)
<i>Superficial pectoral</i>	Number (%)	38.21	(4.28)	31.26	(3.83)	30.53	(2.24)
	Diameter (μm)	37.61	(0.97)	53.58	(1.31)	63.77	(1.06)
	Area (μm ²)	1150.78	(58.51)	2361.57	(115.13)	3287.19	(109.33)
	Percent Area	20.95	(1.06)	32.77	(1.04)	46.28	(1.15)
<i>Teres major</i>	Number (%)	37.06	(2.13)	30.73	(2.15)	32.21	(3.65)
	Diameter (μm)	29.25	(0.72)	34.62	(0.73)	47.42	(0.94)
	Area (μm ²)	694.32	(33.65)	964.08	(39.37)	1818.12	(69.70)
	Percent Area	23.35	(0.78)	26.39	(0.86)	50.25	(1.15)
<i>Supraspinatus</i>	Number (%)	35.74	(3.09)	30.57	(4.39)	33.69	(7.31)
	Diameter (μm)	35.65	(0.89)	49.81	(1.18)	56.26	(1.16)
	Area (μm ²)	1062.91	(51.53)	2100.65	(102.24)	2596.66	(106.41)
	Percent Area	20.96	(0.98)	32.30	(1.11)	46.74	(1.15)
<i>Serratus ventralis</i>	Number (%)	36.50	(4.96)	28.92	(2.58)	34.58	(7.50)
	Diameter (μm)	32.83	(0.92)	44.25	(1.08)	50.11	(0.99)
	Area (μm ²)	896.94	(49.65)	1693.07	(81.88)	2038.60	(79.76)
	Percent Area	23.26	(1.05)	30.31	(1.06)	46.43	(1.15)
<i>Vastus medialis</i>	Number (%)	34.71	(7.66)	27.88	(2.82)	37.40	(8.84)
	Diameter (μm)	36.25	(0.71)	51.72	(1.06)	60.83	(1.12)
	Area (μm ²)	1063.70	(41.48)	2177.65	(88.76)	3007.83	(110.90)
	Percent Area	19.34	(0.56)	30.14	(1.05)	50.51	(1.14)
<i>Longissimus costarum</i>	Number (%)	37.22	(4.24)	27.37	(2.74)	35.41	(3.62)
	Diameter (μm)	29.24	(0.67)	39.97	(0.94)	41.20	(0.67)
	Area (μm ²)	697.05	(31.33)	1320.43	(60.91)	1372.75	(45.06)
	Percent Area	24.47	(0.92)	31.59	(1.02)	43.94	(1.14)
<i>Sartorius</i>	Number (%)	34.16	(2.46)	26.29	(2.40)	39.55	(1.79)
	Diameter (μm)	28.76	(0.69)	35.82	(0.75)	44.18	(0.73)
	Area (μm ²)	670.66	(31.40)	1033.59	(42.51)	1557.20	(51.21)
	Percent Area	20.63	(0.61)	24.57	(1.05)	54.79	(1.12)
<i>Deep pectoral</i>	Number (%)	37.62	(2.41)	25.27	(4.32)	37.11	(6.11)
	Diameter (μm)	27.70	(0.61)	34.60	(0.70)	44.08	(0.68)
	Area (μm ²)	625.02	(27.01)	971.52	(38.59)	1554.78	(47.84)
	Percent Area	22.45	(0.80)	23.79	(0.76)	53.76	(1.12)
<i>Splenius</i>	Number (%)	38.91	(0.37)	23.81	(1.21)	37.28	(0.98)
	Diameter (μm)	31.90	(0.84)	41.39	(1.35)	42.47	(0.94)
	Area (μm ²)	832.29	(43.42)	1447.69	(93.59)	1473.83	(64.92)
	Percent Area	27.29	(0.91)	27.70	(0.80)	45.01	(1.12)

^aMuscles not classified as red or white were classified as intermediate.^bStandard error of the fiber type traits by muscle.

in this experiment were all taken from animals of the same carcass maturity, it was thought that the ultimate size of the animals from the two different carcass weight groups would significantly influence the muscle fiber type profile. No significant differences were noted for the weight of the carcass; this likely can be attributed to small sample numbers per weight group (n=2).

There were nine of 12 muscles from the round that were classified white.

The three muscles from the round that were not classified as white (*Vastus medialis*, *Vastus lateralis*, and *Sartorius*) were all classified as intermediate. In contrast, muscles of the chuck were evenly dispersed between red (10 of 26), intermediate (9 of 26), and white (7 of 26).

An even distribution of muscle fiber type profiles found in muscles from the chuck would suggest a large variability in processing characteris-

tics of muscles of the beef chuck. Conversely, muscles of the beef round may be considered similar, and may not contain as wide a variability in processing characteristics as muscles from the beef chuck.

¹Kevin Kirchofer, graduate student. Chris Calkins, Professor, Animal Science, Lincoln. This project was funded by beef producers through their \$1/head checkoff and produced for the Cattlemen's Beef Board and State Beef Councils.

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Table 3. Muscle fiber type characteristics of white^a muscles.

MUSCLE	Trait	β-Red		α-Red		α-White	
		Mean	(S.E. ^b)	Mean	(S.E. ^b)	Mean	(S.E. ^b)
<i>Vastus intermedius</i>	Number (%)	29.62	(5.69)	9.42	(0.85)	60.96	(5.27)
	Diameter (μm)	38.33	(0.80)	50.02	(1.02)	62.91	(1.46)
	Area (μm ²)	1183.68	(48.69)	2016.41	(82.65)	3202.96	(146.93)
	Percent Area	15.08	(1.27)	8.16	(1.01)	76.76	(1.12)
<i>Gluteus medius</i>	Number (%)	19.52	(0.80)	24.85	(2.00)	55.63	(2.57)
	Diameter (μm)	36.05	(0.85)	42.67	(1.05)	49.82	(1.11)
	Area (μm ²)	1067.63	(49.60)	1478.70	(72.70)	1998.75	(88.01)
	Percent Area	12.82	(0.99)	22.20	(1.00)	64.98	(1.09)
<i>Tensor fascia antibrachii</i>	Number (%)	18.96	(0.68)	30.79	(3.01)	50.25	(2.82)
	Diameter (μm)	30.92	(0.82)	36.56	(0.67)	50.63	(0.89)
	Area (μm ²)	783.87	(42.32)	1076.52	(39.61)	2061.26	(72.50)
	Percent Area	10.02	(0.69)	22.47	(0.92)	67.51	(1.06)
<i>Semitendinosus</i>	Number (%)	24.30	(1.97)	25.99	(1.59)	49.71	(3.27)
	Diameter (μm)	37.88	(0.87)	46.86	(0.88)	60.86	(1.22)
	Area (μm ²)	1161.68	(52.20)	1787.13	(67.92)	2982.32	(121.95)
	Percent Area	13.12	0.66	20.99	0.87	65.89	(1.06)
<i>Biceps femoris</i>	Number (%)	21.72	(1.90)	29.00	(2.31)	49.28	(4.02)
	Diameter (μm)	34.25	(0.78)	46.96	(0.94)	59.46	(1.12)
	Area (μm ²)	956.01	(42.76)	1778.44	(69.96)	2873.14	(106.18)
	Percent Area	10.47	(1.04)	25.16	(0.96)	64.36	(1.05)
<i>Deltoideus</i>	Number (%)	24.84	(3.11)	28.49	(2.24)	46.67	(3.93)
	Diameter (μm)	30.91	(0.81)	38.97	(0.85)	54.71	(1.09)
	Area (μm ²)	780.22	(40.26)	1229.39	(55.16)	2410.05	(96.26)
	Percent Area	11.93	(0.68)	21.74	(0.80)	66.33	(1.05)
<i>Scalenius dorsalis</i>	Number (%)	30.25	(4.00)	23.34	(1.74)	46.42	(4.79)
	Diameter (μm)	24.01	(0.57)	33.26	(0.65)	41.77	(0.77)
	Area (μm ²)	467.05	(21.84)	887.76	(34.74)	1395.26	(51.82)
	Percent Area	14.78	(0.89)	21.19	(0.83)	64.03	(1.04)
<i>Rectus femoris</i>	Number (%)	23.89	(1.43)	29.71	(3.46)	46.40	(3.85)
	Diameter (μm)	32.48	(0.74)	41.57	(0.79)	47.56	(0.89)
	Area (μm ²)	862.22	(39.74)	1405.30	(52.99)	1822.77	(68.55)
	Percent Area	14.31	(0.70)	28.60	(1.05)	57.09	(1.01)
<i>Semimembranosus</i>	Number (%)	26.25	(1.18)	28.63	(2.02)	45.12	(2.39)
	Diameter (μm)	38.58	(0.88)	43.71	(0.97)	46.96	(1.03)
	Area (μm ²)	1241.99	(54.43)	1546.12	(66.73)	1849.35	(76.95)
	Percent Area	21.11	(0.57)	28.51	(0.83)	50.37	(1.00)
<i>Pectineus</i>	Number (%)	31.84	(5.88)	23.59	(3.88)	44.56	(4.79)
	Diameter (μm)	35.17	(0.74)	42.45	(0.92)	53.52	(1.08)
	Area (μm ²)	1001.18	(41.73)	1449.57	(60.74)	2314.59	(92.99)
	Percent Area	19.85	(0.89)	20.98	(0.83)	59.16	(0.98)
<i>Rhomboidus</i>	Number (%)	32.27	(2.67)	23.39	(2.10)	44.34	(4.16)
	Diameter (μm)	31.78	(0.90)	40.56	(1.19)	47.06	(0.91)
	Area (μm ²)	834.34	(46.91)	1370.85	(80.39)	1789.47	(69.34)
	Percent Area	19.86	(0.64)	22.92	(0.80)	57.22	(0.98)
<i>Latissimus dorsi</i>	Number (%)	26.88	(3.44)	28.98	(1.32)	44.14	(4.46)
	Diameter (μm)	32.60	(0.77)	39.43	(1.00)	47.66	(0.94)
	Area (μm ²)	859.65	(38.95)	1269.69	(62.43)	1823.71	(70.99)
	Percent Area	16.98	(0.72)	26.42	(0.40)	56.60	(0.97)
<i>Dorsalis oblique</i>	Number (%)	34.16	(3.10)	21.94	(2.90)	43.90	(3.85)
	Diameter (μm)	26.87	(0.64)	34.61	(0.67)	44.58	(0.82)
	Area (μm ²)	585.57	(27.22)	963.07	(37.54)	1622.82	(59.02)
	Percent Area	18.93	(1.29)	19.45	(1.11)	61.62	(0.93)
<i>Longissimus dorsi</i>	Number (%)	35.01	(1.43)	21.76	(3.37)	43.22	(4.41)
	Diameter (μm)	41.92	(0.91)	54.84	(1.13)	60.68	(1.26)
	Area (μm ²)	1429.91	(60.92)	2431.66	(98.11)	2981.95	(125.64)
	Percent Area	22.28	(1.35)	22.92	(1.03)	54.80	(0.90)
<i>Adductor</i>	Number (%)	29.25	(2.99)	28.24	(3.86)	42.51	(1.87)
	Diameter (μm)	34.57	(0.85)	40.57	(0.90)	47.88	(1.01)
	Area (μm ²)	973.05	(46.79)	1325.44	(58.64)	1846.65	(77.41)
	Percent Area	19.86	(1.18)	26.49	(0.86)	53.65	(0.84)
<i>Gracilis</i>	Number (%)	24.42	(4.12)	33.87	(4.60)	41.71	(3.06)
	Diameter (μm)	31.27	(0.63)	36.47	(0.76)	41.73	(0.76)
	Area (μm ²)	829.71	(32.68)	1078.56	(44.25)	1399.42	(51.28)
	Percent Area	16.17	(1.37)	32.08	(1.30)	51.75	(0.61)

^aMuscles containing greater than 40% α-white fiber numbers were classified as white.^bStandard error of the fiber type traits by muscle.