2002 MAFMA Final Report

Project Title:	**Application of Value Cut Technology to Holstein Beef**
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1. Objective Summary

Our objective was to determine the acceptability of innovative value cuts from the chuck and round of Holstein beef carcasses.

2. Objective Accomplishments

Three groups of cattle were used: 1) Holstein steers (**Holstein)**, 2) Holstein steers administered steroid growth promoting implants (Ralgro on days 1 and 112 and Synovex-S on day 196 in the feedlot; **Holstein-Implant)**, and Angus steers implanted with Ralgro on day 1 and Synovex-S on day 84 in the feedlot (**Angus)**. Initial weights of Holstein and Angus cattle in the feedlot were 173 and 435 kg, respectively. Steers were harvested at the Smithfield Beef processing facility in Plainwell, MI. Following USDA carcass grade determination, carcasses from 14 Holstein, 14 Holstein-implant, and 14 Angus cattle were selected based on similar weight (~368 kg) and quality grade (Choice). A section of *longissimus* muscle (**LD)** between the 9^{th} and 12^{th} rib of each carcass was removed for analysis. Value cut muscles included *triceps brachii* long head (**TBLG**; shoulder center steaks), *triceps brachii* lateral head (**TBLT**; shoulder top steaks), *infraspinatus* (**IS**; top blade/flat iron steaks), *teres major* (**TM**; shoulder tender medallions), *rectus femoris* (**RF**; round tip center steaks), *vastus lateralis* (**VL**; round tip side steaks) and *biceps femoris* (**BF**; bottom round steaks). We intended to analyze the *spinalis dorsi* muscle, although no specific value cut for this muscle has been created to date. Unfortunately, the limited quantity of *spinalis dorsi* present in the rib sections obtained did not permit detailed analysis of this muscle. Muscles were vacuum packaged and aged for 14 days at 4°C. Beef value cuts were fabricated according to current recommendations (Beef Value Cuts, NCBA, 2001)

Biceps femoris and TM muscles from Angus were heavier (P<0.05) than those from Holstein, but not Holstein-implant carcasses (**Table 1**). Angus TBLG, IS and RF muscles were shorter ($P < 0.05$) and tended to be thicker than those of the Holstein carcasses.

Proximate composition and collagen content were determined on samples frozen and subsequently milled with Dry Ice. Carbon dioxide was allowed to evaporate for two days at 4°C. Dry matter content was measured by air-drying (AOAC, 1995; Method

950.46B). Total fat content was quantified using a Soxtec Fat Analyzer (AOAC, 1995; Solvent Extraction Method 991.36; Tecator, Hoganas, Sweden). Crude protein was determined using combustion method 992.15 (AOAC, 1995; Leco FP-2000, Leco Corp., St. Joseph, MO). Total collagen was quantified in duplicate for each sample using AOAC Official Method 990.26 (Hydroxyproline in Meat and Meat Products). With the exception of the LD and VL, muscles from non-implanted Holstein carcasses had a slightly lower (P<0.05) percentage protein than Angus muscles. Only the RF muscle of Holstein-implanted carcasses had less protein than that of Angus. Holstein TBLG and TBLT muscles also had a higher percent fat than those from Angus. In general, only minor differences in muscle composition between breeds were observed. Likewise, the collagen contents of muscles from Angus and Holstein carcasses were similar, with the exception of the Holstein TBLG, which had higher collagen that the Angus TBLG (7.4 *vs* 6.3 mg/g tissue, respectively; P<0.05). *Longissimus* and TM muscles had the lowest total collagen (~5.3 mg/g), whereas the VL muscle had the highest collagen concentration (10.2 mg/g).

Water-holding capacity of muscles was determined by measuring fluid loss from vacuum packaged muscles (2 to 14 d postmortem), diced muscle samples subjected to centrifugation (30,000 x ***g***), and retail cuts packaged on Styrofoam trays for 7 days. No consistent differences in fluid loss from vacuum packaged or centrifuged samples were observed among muscles due to breed or implant treatment. Interestingly, when value cuts were held under retail conditions, all steaks from implanted Holstein steers, except IS steaks, retained more moisture than those of either the Angus or non-implanted Holsteins (**Table 2**). The reason for this difference in water-holding capacity is unclear, and does not appear to be related to ultimate muscle pH (14 d postmortem). The ultimate pH of Angus LD was slightly lower (5.58 *vs* 5.64; $P < 0.05$) than both implanted and non-implanted Holstein muscles, but ultimate pH of other muscles was similar across groups.

Color (CIE L*a*b*) of the oxygenated muscle surface was measured using a Hunter MiniScan XE (Restin, VA). Relative contents of myoglobin, oxymyoglobin and metmyoglobin were estimated based on spectral scans of the steak surface on day 3 and 7 of storage under simulated retail conditions. Two independent evaluators also scored muscle color and discoloration. Holstein muscles were generally darker red than Angus muscles, and several Holstein muscles began to discolor more readily than those of Angus (**Table 3**). By day 7, all muscle types were exhibiting discoloration, and only the Holstein LD, TM and VL were not discolored to a greater extent than comparable muscles from Angus. Visual observations were supported by changes in objective color data and increases in the proportion of metmyoglobin. In an attempt to help explain observed color differences between Holstein and Angus muscles, we measured total heme pigment. With the exception of the LD, Angus-derived muscles consistently had lower ($P < 0.05$) concentrations of total heme pigment than those of Holstein-derived muscle (**Table 4**). There were no differences in heme pigment between the Holstein groups.

Muscles were cut into 2.54 cm-thick steaks, which were broiled at 103°C in a clamshell grill (Taylor model QS24, Rockton, IL) to an internal temperature of 70°C. Six cores (1.27 cm diameter) were mechanically removed for Warner-Bratzler shear force determination using a TA-HDi Texture Analyzer (Texture Technologies Corp., Scarsdale, NY). Warner-Bratzler shear force values were similar among breed and implant groups. As expected, shear values varied considerably among muscles, with the IS being the most tender (2.0 kg overall) and VL being the least tender (5.2 kg overall). A trained panel performed sensory analysis. Sensory data are shown for each muscle in **Tables 5 – 12.** Holstein and Angus LD muscles were rated similarly for juiciness and tenderness. Holstein value cuts were generally slightly more tender than those from Angus. Additionally, Holstein BF, TBLG, and IS were perceived to be more juicy than Angus or Hostein-implant product. Although off-flavor scores were generally low for all muscles, all seven value cut muscles from Holstein beef had lower ($P < 0.05$) off-flavor scores than those cuts from Angus. Flavor intensity was similar for most muscles between breeds. Collectively, these sensory data indicate that Holstein value cuts may be slightly more desirable than those of Angus, due to advantages in tenderness and less off-flavor.

3. Unexpected findings, if any

Several unexpected and as yet unexplained findings were observed. These include: improved water-holding capacity of Holstein-implant beef during retail display, more pronounced discoloration and greater heme-pigment concentration of Holstein value cut muscles, and the advantages in tenderness, juiciness and lack of off-flavor observed in several Holstein *vs* Angus value cut muscles. Although color instability of some Holstein beef muscles has been previously reported, the magnitude and prevalence of this problem in five of the eight muscles examined was not expected.

4. Practical impacts of research efforts.

a. Short Term Impacts

Beef value cut manufacturing requires unconventional subprimal and retail cut fabrication, which has not yet been widely adopted by beef processors. Consistent with our objective, we examined quantitative and qualitative properties of eight muscles from Angus and Holstein carcasses. For most of the traits evaluated, Holstein and Angus value cut muscle characteristics were both acceptable. Sensory characteristics of Holstein value cuts were generally as good or better than those from Angus beef. However, when compared with Angus value cut muscles, muscles from Holstein cattle generally contained more heme pigment, and five of the muscles exhibited inferior color stability under retail storage conditions. These findings demonstrate a need to understand the cause(s) of inferior color stability of Holstein muscles, so that effective strategies can be implemented to improve color stability of Holstein value cut muscles during retail display.

b. Long Term Impacts

Improving color stability of fresh Holstein beef and adoption of beef value cut technology is expected to 1) improve the value of Holstein beef carcasses by maximizing the use of underutilized muscles of the chuck and round, thereby creating steaks out of more of the carcass, 2) provide highly desirable beef products to consumers at a moderate price to fill the void between steaks from the loin or rib and ground beef, and 3) provide more variety of beef products for foodservice operators and consumers.

Table 1. Trimmed muscle weights (kg).

	Angus		Holstein		Holstein-Implant		Overall	
Muscle	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**
BF	3.92[a]	0.18	3.62[b]	0.26	3.71[ab]	0.39	3.75	0.31
TBLG	2.04	0.13	1.92	0.18	2.00	0.23	1.99	0.18
TBLT	0.68[a]	0.10	0.62[ab]	0.09	0.61[b]	0.06	0.64	0.09
IS	1.72	0.11	1.78	0.25	1.73	0.15	1.75	0.18
TM	0.34[a]	0.03	0.30[b]	0.05	0.32[ab]	0.03	0.32	0.04
VL	1.75	0.14	1.74	0.18	1.71	0.16	1.73	0.16
RF	1.61	0.11	1.62	0.17	1.64	0.12	1.62	0.14

[a,b]Within a row, means without a common superscript letter differ ($P < 0.05$).
Abbreviations used within the table: *biceps femoris* (BF), *triceps brachii* long head (TBLG), *triceps brachii* lateral head (TBLT), *infraspinatus* (IS), *teres major* (TM), *vastus lateralis* (VL), *rectus femoris* (RF)

Table 2. Percentage drip loss from steaks held in retail display for 7 days.

	Angus		Holstein		Holstein-Implant		Overall	
Muscle	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**
LD	1.62[a]	0.18	1.66[a]	0.31	1.39[b]	0.39	1.56	0.32
BF	2.87[a]	0.64	3.09[a]	0.42	2.22[b]	0.57	2.73	0.66
TBLG	3.26[a]	0.52	3.36[a]	0.55	2.64[b]	0.32	3.09	0.57
TBLT	3.95[ab]	0.39	4.14[a]	0.69	3.59[b]	0.50	3.89	0.58
IS	2.99	0.69	2.56	0.53	3.01	0.79	2.85	0.69
VL	3.47[a]	0.33	3.48[a]	0.27	3.08[b]	0.25	3.34	0.34
TM	3.32	0.50	3.55	0.44	3.19	0.51	3.38	0.49
RF	2.96[a]	0.28	3.14[a]	0.33	2.55[b]	0.25	2.88	0.38

[a,b]Within a row, means without a common superscript letter differ ($P < 0.05$).

Table 3. Subjective color[c] and discoloration[d] scores after 3 days of retail display.

		Angus		Holstein		Holstein-Implant		Overall	
Muscle		**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**
LD	**color**	2.07[a]	0.48	2.31[ab]	0.63	2.71[b]	0.61	2.37	0.62
	dis	1.00	0	1.08	0.28	1.00	0	1.02	0.16
BF	**color**	2.71[a]	0.51	3.36[b]	0.46	3.61[b]	0.49	3.23	0.61
	dis	1.18[a]	0.32	1.82[b]	0.46	1.68[b]	0.50	1.56	0.51
TBLG	**color**	3.00[a]	0	3.64[b]	0.50	3.64[b]	0.63	3.43	0.55
	dis	1.00[a]	0	1.71[b]	0.47	1.43[b]	0.65	1.38	0.54
TBLT	**color**	3.29[a]	0.47	3.93[b]	0.48	3.86[b]	0.54	3.69	0.56
	dis	1.21	0.43	1.43	0.51	1.29	0.47	1.31	0.47
IS	**color**	3.29[a]	0.47	3.86[b]	0.36	3.83[b]	0.72	3.65	0.58
	dis	1.21	0.43	1.50	0.65	1.50	0.52	1.40	0.55
TM	**color**	2.86	0.54	3.14	0.36	3.22	0.44	3.05	0.47
	dis	1.86	0.77	1.79	0.70	1.89	0.78	1.84	0.73
VL	**color**	3.00[a]	0.54	3.50[b]	0.52	3.50[b]	0.48	3.34	0.55
	dis	1.58[a]	0.40	1.96[b]	0.46	1.89[b]	0.29	1.82	0.42
RF	**color**	2.62[a]	0.42	3.04[b]	0.37	3.25[b]	0.43	2.98	0.47
	dis	2.04	0.25	2.11	0.21	2.07	0.18	2.07	0.21

[a,b]Within a row, means without a common superscript letter differ ($P < 0.05$).
[c,d]Color and discoloration scores are on a scale of 1-5. For color, 1 is extremely bright red and 5 is dark red. For discoloration, 1 is no discoloration (or no evidence of browning) and 5 is extremely discolored (or brown).

Table 4. Total heme pigment (mg pigment per gram of muscle wet weight).

	Angus		Holstein		Holstein-Implant		Overall	
Muscle	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**
LD	3.55	0.52	3.81	0.41	3.76	0.41	3.71	0.45
BF	4.61[a]	0.49	5.41[b]	0.48	5.38[b]	0.41	5.13	0.60
LG	4.63[a]	0.48	5.68[b]	0.58	5.53[b]	0.61	5.28	0.72
LT	4.88[a]	0.73	5.83[b]	0.64	5.57[b]	0.60	5.43	0.76
IS	5.55[a]	0.40	5.95[b]	0.39	6.14[b]	0.54	5.86	0.50
VL	4.24[a]	0.68	5.27[b]	0.58	4.99[b]	0.59	4.85	0.734
TM	4.23[a]	0.40	5.03[b]	0.41	4.98[b]	0.49	4.71	0.57
RF	3.94[a]	0.41	4.51[b]	0.57	4.70[b]	0.66	4.39	0.63

[a,b]Within a row, means without a common superscript letter differ ($P < 0.05$).

Table 5. Sensory evaluation[a] – *Longissimus dorsi*.

Attribute	Angus Mean	Angus Std dev	Holstein Mean	Holstein Std dev	Holstein-Implant Mean	Holstein-Implant Std dev
Juiciness	5.55	0.84	5.54	0.73	5.38	0.83
Tenderness	5.09	0.96	5.39	0.88	5.32	0.83
Overall Tenderness	5.16	0.84	5.41	0.87	5.43	0.74
Connective Tissue	5.75	0.92	5.69	1.09	5.72	1.05

(No significant differences.)
[a]Sensory attributes are scored using 8-point rating scales (1=extremely dry (juiciness), extremely tough (myofibrillar and overall tenderness), extreme amount (amount of connective tissue) and where 8= extremely juicy, extremely tender, and none)

Table 6. Sensory evaluation [c] – *Biceps femoris*.

Attribute	Angus Mean	Angus Std dev	Holstein Mean	Holstein Std dev	Holstein-Implant Mean	Holstein-Implant Std dev
Juiciness	4.95^{a}	1.01	5.48^{b}	0.90	4.82^{a}	0.97
Tenderness	4.54^{a}	0.93	5.13^{b}	0.84	4.50^{a}	0.85
Overall Tenderness	4.38^{a}	0.90	4.88^{b}	0.97	4.32^{a}	0.87
Connective Tissue	4.08	1.16	4.41	1.29	4.09	1.23
Off-flavor	1.62^{a}	0.98	1.02^{b}	0.17	1.11^{b}	0.32
Flavor Intensity	4.29	0.90	4.21	1.07	4.36	0.97

[a,b]Within a row, means without a common superscript letter differ ($P < 0.05$).
[c] Sensory attributes are scored using 8-point rating scales (1=extremely dry (juiciness), extremely tough (myofibrillar and overall tenderness), extreme amount (amount of connective tissue), no off-flavor, extremely bland (beef flavor intensity), and where 8= extremely juicy, extremely tender, no connective tissue, abundant off-flavor, and extremely intense flavor)

Table 7. Sensory evaluation – *Triceps brachii*, long head.

Attribute	Angus Mean	Angus Std dev	Holstein Mean	Holstein Std dev	Holstein-Implant Mean	Holstein-Implant Std dev
Juiciness	5.13^{a}	0.92	6.05^{c}	0.76	5.72^{b}	0.80
Tenderness	5.43^{a}	0.77	5.88^{b}	0.71	5.60^{ab}	0.83
Overall Tenderness	5.54^{a}	0.68	5.90^{b}	0.69	5.76^{ab}	0.70
Connective Tissue	6.08^{ab}	0.82	6.23^{b}	0.74	5.94^{a}	0.81
Off-flavor	1.59^{a}	0.86	1.15^{b}	0.37	1.21^{b}	0.40
Flavor Intensity	4.60^{a}	0.96	4.91^{b}	0.71	4.79^{ab}	0.72

[a,b,c]Within a row, means without a common superscript letter differ ($P < 0.05$)
Sensory attributes are scored as described for Table 6.

Table 8. Sensory evaluation – *Triceps brachii*, lateral head.

	Angus		Holstein		Holstein-Implant	
Attribute	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**
Juiciness	5.39	0.89	5.60	0.75	5.32	0.85
Tenderness	5.22[a]	0.84	5.54[b]	0.88	4.97[a]	0.73
Overall Tenderness	5.24[a]	0.77	5.55[b]	0.79	4.99[a]	0.61
Connective Tissue	5.53[a]	0.86	5.71[a]	1.02	5.12[b]	0.87
Off-flavor	1.51[a]	0.72	1.15[b]	0.39	1.17[b]	0.46
Flavor Intensity	4.75[a]	0.86	4.65[ab]	0.91	4.45[b]	0.94

[a,b]Within a row, means without a common superscript letter differ (*P* < 0.05).
Sensory attributes are scored as described for Table 6.

Table 9. Sensory evaluation – *Infraspinatus*.

	Angus		Holstein		Holstein-Implant	
Attribute	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**
Juiciness	5.60[a]	0.83	5.91[b]	0.81	5.58[a]	0.86
Tenderness	5.74[a]	0.93	6.11[b]	0.89	5.76[a]	0.85
Overall Tenderness	5.83[ab]	0.76	6.11[b]	0.84	5.74[a]	0.82
Connective Tissue	5.99	1.04	6.02	1.10	6.07	0.97
Off-flavor	1.45[a]	0.68	1.16[b]	0.43	1.05[b]	0.26
Flavor Intensity	4.79	1.01	4.95	0.84	4.78	0.86

[a,b]Within a row, means without a common superscript letter differ (*P* < 0.05).
Sensory attributes are scored as described for Table 6.

Table 10. Sensory evaluation – *Teres major*.

	Angus		Holstein		Holstein-Implant	
Attribute	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**
Juiciness	5.55	0.93	5.63	0.88	5.40	0.97
Tenderness	5.77[a]	0.80	6.24[b]	0.72	5.83[a]	0.79
Overall Tenderness	5.81[a]	0.71	6.12[b]	0.66	5.76[a]	0.72
Connective Tissue	5.99	1.01	6.11	0.95	5.84	0.99
Off-flavor	1.40[a]	0.62	1.17[b]	0.40	1.24[ab]	0.47
Flavor Intensity	5.10	0.87	5.09	0.94	4.87	0.91

[a,b]Within a row, means without a common superscript letter differ (*P* < 0.05).
Sensory attributes are scored as described for Table 6.

Table 11. Sensory evaluation – *Rectus femoris*.

	Angus		Holstein		Holstein-Implant	
Attribute	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**
Juiciness	5.12	1.07	5.31	1.19	5.33	1.02
Tenderness	5.41[a]	0.68	5.73[b]	0.78	5.52[ab]	0.81
Overall Tenderness	5.54	0.61	5.75	0.74	5.65	0.78
Connective Tissue	6.23	0.77	6.37	0.84	6.23	0.78
Off-flavor	1.49[a]	0.64	1.13[b]	0.42	1.26[b]	0.54
Flavor Intensity	5.11[a]	1.01	4.72[b]	0.98	4.78[ab]	0.87

[a,b]Within a row, means without a common superscript letter differ ($P < 0.05$).
Sensory attributes are scored as described for Table 6.

Table 12. Sensory evaluation – *Vastus lateralis*.

	Angus		Holstein		Holstein-Implant	
Attribute	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**
Juiciness	5.18	0.88	5.21	1.09	5.17	1.06
Tenderness	4.89[a]	0.87	5.18[ab]	0.73	5.22[b]	0.98
Overall Tenderness	4.98[a]	0.84	5.34[b]	0.73	5.26[ab]	0.91
Connective Tissue	5.28	1.14	5.50	0.99	5.25	1.18
Off-flavor	1.39[a]	0.81	1.09[b]	0.44	1.08[b]	0.35
Flavor Intensity	4.35	0.73	4.48	0.93	4.50	1.08

[a,b]Within a row, means without a common superscript letter differ ($P < 0.05$).
Sensory attributes are scored as described for Table 6.