THE SCIENTIFIC BASIS OF THE *Certified Angus Beef*® BRAND CARCASS SPECIFICATIONS

Written by:
P. D. Bass

Introduction

The *Certified Angus Beef*® (CAB®) brand specifications were initially deployed in 1978 when it became the first branded beef program to be certified by the USDA Agricultural Marketing Service. Since its inception the CAB carcass specifications have been adjusted slightly, once in 2007 and again in 2014, but the focus on consistency, efficacy and palatability have never been compromised. Current CAB carcass specifications consist of 10 defined parameters that must be met in addition to the live phenotypic specification. These continue to provide a consistent, high-quality eating experience for the consumer while helping promote the best of the Angus cattle breed. The objective of this document is to compile the supporting scientific literature for the CAB live animal and carcass specifications to substantiate the scientific platform on which the brand has been established.

Identifying Angus-type Cattle

Table 1. 2013 Mean production and carcass characteristic values of breeds with commercial significance in North America*

Breed	Birth Wt.(lb.)	Weaning Wt. (lb.)	Yearling Wt. (lb.)	Carcass Wt. (lb.)	Marbling Score (4.00=Sl⁰⁰, 5.00=Sm⁰⁰)
Angus	86.6	570.2	1041.9	904.9	6.14
Hereford	90.9	562.8	1004.2		5.36
Red Angus	87.2	550.5	1009.9	886.6	5.72
Shorthorn	92.3	537.5	994.3	861.4	5.41
South Devon	91.0	555.4	1008.7	877.9	5.92
Beefmaster	90.9	566.3	1000.2		
Brahman	97.7	583.7	988.5	845.5	4.97
Brangus	89.9	558.7	1005.1	883.9	
Santa Gertrudis	92.1	565.2	1001.2	870.8	4.97
Braunvieh	90.4	542.5	973.8	848.3	
Charolais	94.0	585.9	1042.2	894.2	5.25
Chiangus	90.9	536.6	977.2	862.4	5.36
Gelbvieh	88.6	566.2	1020.9	879.1	5.34
Limousin	89.9	567.5	1002.5	885.4	4.94
Maine-Anjou	91.2	541.0	978.6	856.3	5.04
Salers	88.7	558.1	1007.6	865.2	5.46
Simmental	90.6	578.3	1035.3	903.4	5.35
Tarentaise	89.3	565.9	994.3		

* Adapted from a table published by Kuehn and Thallman, 2015

Prior to any carcass being evaluated for the CAB program, the live animal phenotypic specification must coincide with the USDA Schedule GLA specification for identifying cattle with Angus influence

(USDA, 2016; USDA, 2015). The phenotypic specification for USDA Schedule GLA identifies cattle as being predominantly (51% or greater) solid black (USDA, 2016). The live animal specification aids in identifying predominantly black-hided cattle that likely have Angus influence, including cross-bred cattle, because the black hide color in the Angus breed comes from a dominant qualitative gene (Ibsen, 1933). Historically, cattle with Angus genetics have been observed as tending to have superior carcass quality and palatability traits (Adams et al., 1982; Chambaz et al., 2003; Wheeler et al., 2004; Stolowski et al., 2006; Wheeler et al., 2010; Sexten et al., 2012; Miguel et al., 2014). Research published by the United States Meat Animal Research Center shows that cattle sired by Angus bulls attain very desirable traits in regards to growth as well as carcass merit when compared to all other breeds of commercial significance (Kuehn and Thallman, 2015; Table 1). However, merely having an Angus phenotype is only a first step in qualifying an animal for the CAB brand; 10 carcass traits must be evaluated and confirmed as within specification prior to formal certification of the carcass.

Marbling: Modest^{00} or Higher Marbling and Medium to Fine Marbling Texture

The amount of marbling in beef has an effect on beef palatability (McBee and Wiles, 1967; Smith et al., 1985; Savell et al., 1987; O'Quinn, 2012; Emerson et al., 2013; Corbin et al., 2015); palatability is defined as the evaluated components of flavor, tenderness, and juiciness (AMSA, 2016). Increases in marbling will improve the probability of having a positive eating experience (Emerson et al., 2013; Figure 1).

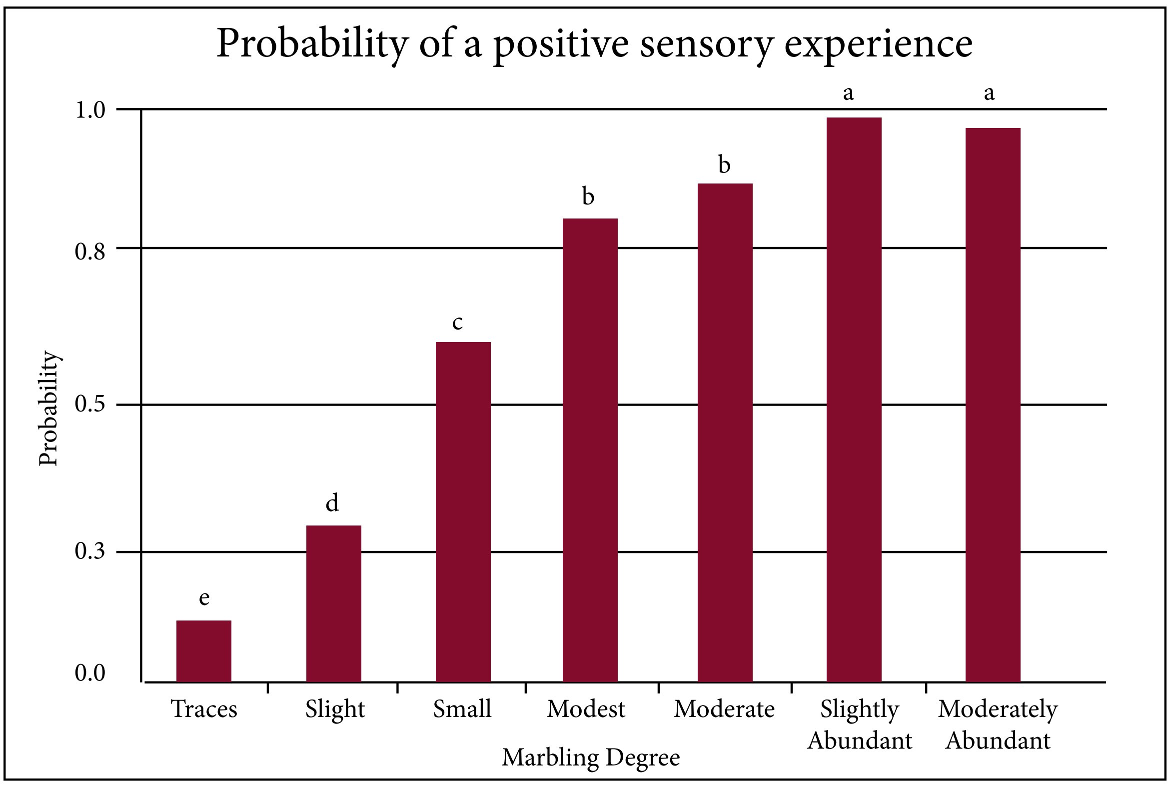

Figure 1. Effect of marbling degree on the probability of a steak receiving a positive rating for overall sensory experience. Emerson et al., 2013. a-e Probabilities that do not share a common superscript letter differ, $P < 0.05$

CAB marbling specifications require a Modest^{00} (CAB Prime minimum marbling requirement is Slightly Abundant^{00}) amount of marbling as a minimum with medium to fine marbling texture, both identified by the official USDA marbling score standards (Figures 2 and 3) and evaluated from the ribeye at the 12th and 13th rib interface of the beef carcass (USDA, 1997).

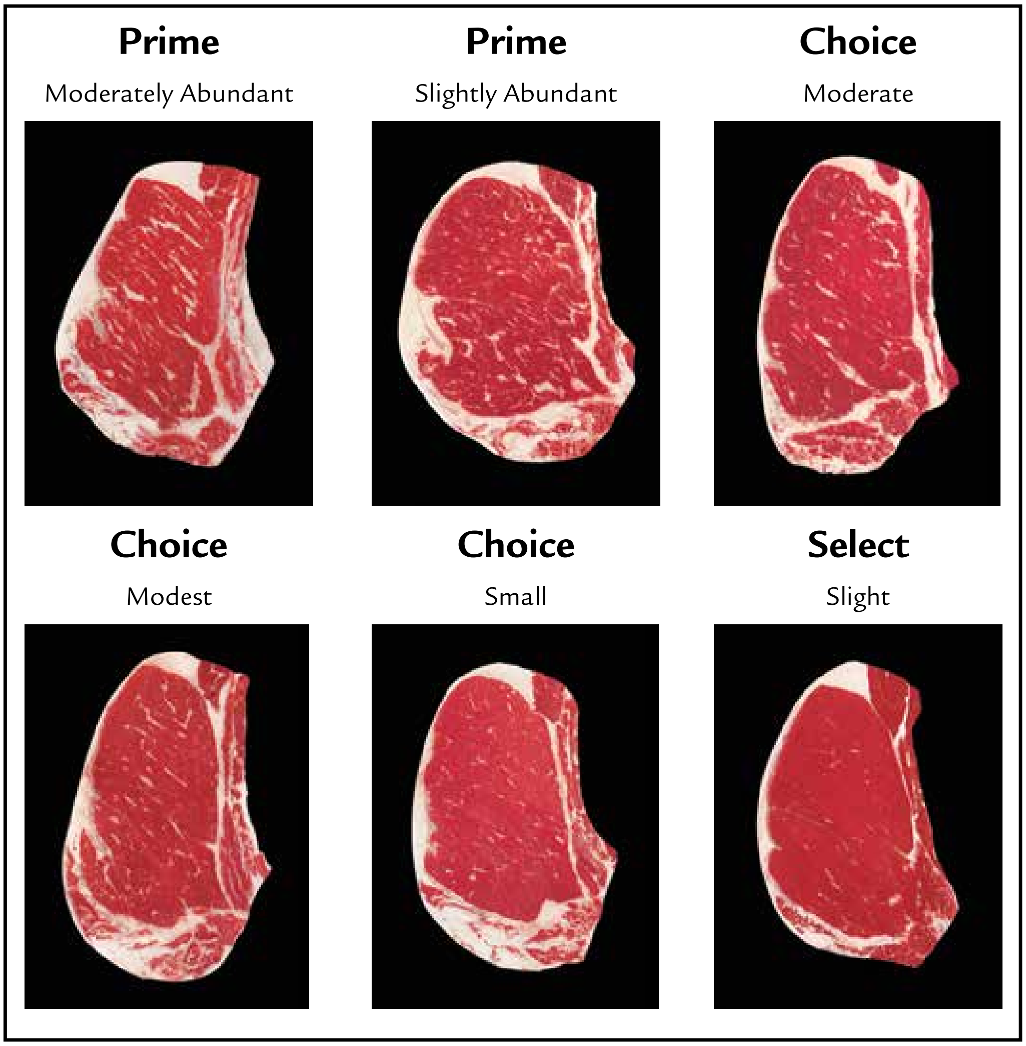

Figure 2. The above illustrations are reduced reproductions of the official Marbling photographs prepared for the U.S. Department of Agriculture and available from the National Cattlemen's Beef Association

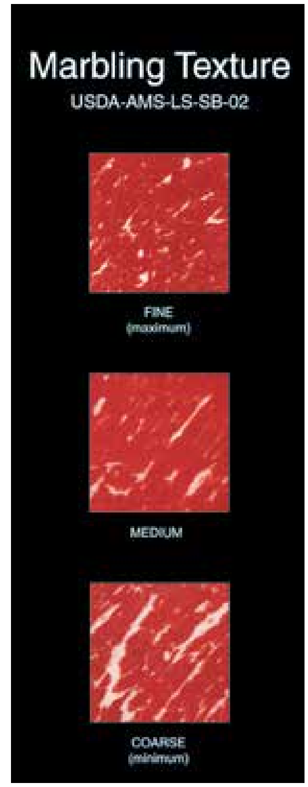

Figure 3. The above illustrations are reduced reproductions of the official Marbling photographs prepared for the U.S. Department of Agriculture and available from the National Cattlemen's Beef Association.

Emerson et al. (2013) reported marbling accounted for 40% and 23% of the variation in tenderness among Longissimus muscle (LM) steaks evaluated by trained sensory panel and Warner-Bratzler Shear Force (WBSF) evaluation, respectively. These data reported the Small marbling treatment less tender when measured by WBSF than the Modest and Moderate marbling treatments; interestingly, there were no significant difference in WBSF between the Modest and Moderate treatments. Nelson et al. (2004) identified significant improvements in tenderness of CAB brand strip steaks compared to commodity Choice and Select strip steaks. The predominant difference between treatments was marbling level. CAB steaks contained only Modest or Moderate marbling and the USDA Choice contained predominantly Small marbling with some Modest and Moderate representative of the marbling distribution within carcasses of the Choice grade at the time of the study (Small = 76%, Modest = 18%, Moderate = 6%); Select contained only Slight marbling. Furthermore, Nelson et al. (2004) identified the probability of encountering a tough steak from the CAB brand, USDA Choice, and USDA Select as 1 in 50, 1 in 13, and 1 in 6, respectively, based on a WBSF level of less than 3.9 kg; according to Shackelford et al. (1991) a WBSF of 3.9 kg should have a 68% chance of a steak being rated as "slightly tender." Gruber et al. (2006) found 11 muscles from an upper two-thirds USDA Choice to be superior to the USDA Select *Longissimus lumborum* (LL) muscle at a constant 21 days of postmortem aging; 7 of those muscles would be considered end-meat cuts (Table 2). Moreover, Gruber et al. (2006) found 6 of the upper two-thirds USDA Choice muscles with greater tenderness than the USDA Select LL as well as having significantly better tenderness than their USDA Select muscle counterparts (Table 2).

Table 2. Warner-Bratzler shear force (kg) for USDA Select and upper two-thirds USDA Choice (Mt/Md)[1]

Muscle	Common Name	USDA Select	Upper 2/3 USDA Choice
Longissimus lumborum	Strip Loin	4.52	3.66*†
Complexus	Chuckeye	4.96	4.03*†
Infraspinatus	Top Blade (Flat Iron)	3.67	3.25*
Psoas major	Tenderloin	3.59	3.36*†
Rectus femoris	Knuckle Center	4.16	3.81*†
Serratus ventralis	Underblade	3.91	3.48*†
Spinalis dorsi	Ribeye Cap	3.70	3.48*
Tensor fasciae latae	Tri Tip	4.07	3.77*
Teres major	Shoulder Tender	4.20	3.61*†
Triceps brachii	Clod Heart	4.28	3.99*
Vastus medialis	Knuckle Side (adjacent)	4.02	3.89*

1 Table adapted from Gruber et al., 2006
* Mean differs significantly from the USDA Select *Longissimus lumborum* mean ($P<0.05$), LSD = 0.31.
†Mean differs significantly from the USDA Select muscle of the same name ($P<0.05$), LSD = 0.31.

Even with known mechanical WBSF tenderness held constant, Corbin et al. (2015) demonstrated that higher marbled beef still resulted in a perceived more tender product, likely due to the "halo-effect" of the increased juiciness from the greater amount of marbling. Marbling is believed to contribute to the tenderness of a whole-muscle meat product through the following theories (Smith and Carpenter, 1974; Savell and Cross, 1988; Wood, 1995; Warriss, 2010):

Bite Theory/Dilution Factor: Given a similar volume of meat, a piece of meat with more marbling will be more tender as a result of the fat being less dense than a higher protein counterpart of the same volume. The less dense marbling dilutes the amount of muscle fiber bundles and thus accounts for an easier bite mechanically.
Lubrication Theory: When melted during the cooking process, marbling produces a lubricating sensation on the bite, resulting in a perceived tenderness.

Numerous studies confirm the increased desirability of greater marbled product when compared to lesser marbled product with regard to flavor (Killinger et al. 2004; Behrends et al., 2005; O'Quinn et al., 2012; Hunt et al., 2014; Webb et al., 2015). Legako et al. (2015) identified significant differences in consumer beef flavor acceptability between "Upper 2/3" (Modest and Moderate marbling) treatments and Low Choice (Small marbling) treatments; the higher marbled cuts from the "Upper 2/3" treatment group were found to be more acceptable to the consumer panel than the Low Choice counterparts. Holding the "Angus" phenotypic identifier constant and removing the tenderness variable, O'Quinn (2012) confirmed a significant flavor difference between CAB and a Low Choice (Small marbling) Angus product where the CAB was found to be more desirable to untrained discriminating sensory panelists; the main difference was the higher marbling deposition in the CAB product. Beef with a higher amount of marbling that is known to originate from a grain-finished management system has been described as having a desirable, buttery flavor thought to be an impactful flavor characteristic for beef consumers (Emerson et al., 2013; Acheson, 2014). Beef flavor is influenced greatly by finishing feed. Although flavor preferences can vary depending on the individual consumer, grain-finished beef tends to be widely accepted among consumers over grass- or forage-finished beef (Maughan et al., 2012; O'Quinn, 2012; Van Elswyk and McNeill, 2014; Corbin et al., 2015; Webb et al., 2015). Grain finishing results in a greater deposition of desirable monounsaturated fatty acids, which result in more pleasing flavor characteristics than do grass- or forage-finishing beef production models (Van Elswyk and McNeill, 2014). In North America the predominant finishing feed is corn, however cattle in certain regions may be finished on primarily barley or wheat-based rations and also at times potato byproducts. Regardless of the finishing feed, as long as it contains a high starch content, cattle can convert it into highly desirable marbling with similar palatability results (Busboom et al., 2000; Nelson et al., 2000).

Marbling improves juiciness as a result of the melting process during cooking. When cooked, marbling translocates along perimysial tissue to provide a consistent and uniform distribution of perceived juiciness (Aberle et al., 2001). Research continues to verify the improvements in juiciness with increases of marbling (O'Quinn et al., 2012; Emerson et al., 2013; Corbin et al., 2015). Steak juiciness declines as overall degree of doneness increases (Lorenzen et al., 1999; Savell et al., 1999); therefore, greater marbling amounts can ensure a better chance of maintaining a juicy eating experience for consumers who prefer their steaks cooked to a higher temperature. Cashman et al. (2015) reported that strip steaks from USDA Prime and Top Choice (Modest and Moderate marbling) resulted in higher juiciness ratings compared to that of USDA Low Choice (Small marbling) and Select beef among consumers within common degrees of doneness. Degree of doneness and steak marbling levels are independent of each other with regard to level of juiciness (Cashman et al., 2015; O'Quinn et al., 2015).

Hunt et al. (2014) evaluated four muscles from carcasses identified as either USDA Select or upper two-thirds USDA Choice (Modest^{50} to Moderate^{50}). Results found that not only were flavor, tenderness, and juiciness superior in nearly all of the upper two-thirds Choice muscles compared to their USDA Select counterparts, but further the *Gluteus medius* (top sirloin center) and *Serratus ventralis* (underblade center) were superior in the overall liking consumer evaluation, compared to the USDA Select LL (strip loin). This demonstrates that improvements in marbling can allow for a cut that has long been thought of as possessing a lesser eating satisfaction potential (e.g., top sirloin) to excel in palatability over a cut thought to have greater eating satisfaction potential (e.g., striploin). Findings such as this can allow for beef consumers to purchase a high quality cut of lower cost instead of a lower quality cut at a higher cost.

The CAB requirement of medium to fine marbling texture ensures even distribution of marbling throughout the ribeye, making certain the consumer experiences not only a palatable bite but also a consistent meal. Moody et al. (1970) outlined that mechanical tenderness can be negatively affected by coarser marbling in the beef ribeye. It is suggested that the finer marbling may be a result of less perimysial connective tissue, resulting in a more tender piece of meat (Moody et al., 1970).

A Maturity

The USDA beef grading system has historically used cattle physiological maturity as an indicator of potential eating quality (USDA, 1997). For assessment of carcass physiological maturity, the system evaluates the ossification level of the vertebral column and adjacent tissues as well as the color and texture of the ribeye at the 12th and 13th rib interface. The physiological indicators of maturity allow a USDA grader to identify a beef carcass as one of the 5 maturity groups approximating physiological age and identified by letters A through E: A) 9 to 30 months old, B) 30 to 42 months, C) 42 to 72 months, D) 72 to 96 months, and E) greater than 96 months old. In younger animals, predominantly cartilaginous tissue will be located at the tip of the dorsal processes of the carcass vertebrae; carcasses from more mature animals will show signs of ossification in the vertebrae as well as fusing of vertebrae in cases of more advanced maturity (Smith et al., 1982; Smith et al, 1988). Ossification of the vertebrae, in general, progresses from the rear of the carcass toward the head (Tatum, 2007). Examples of A- and C-maturity dorsal processes of the thoracic vertebrae are illustrated in Figure 4.

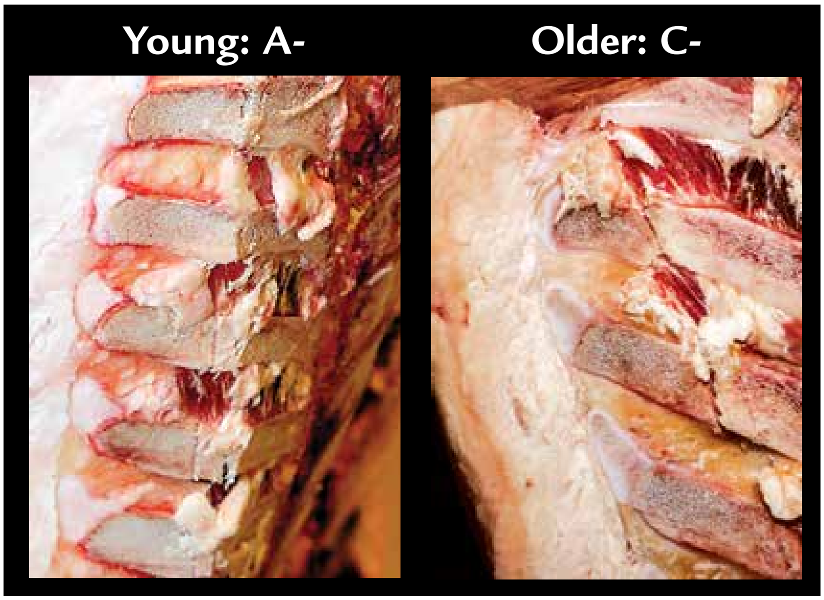

Figure 4. Comparison of skeletal maturity. Thoracic vertebrae from A and C maturity carcasses.

Along with ossification of the cartilaginous tissue in the vertebral column, muscles of the beef carcass become darker as animals mature, a result of increased concentration of myoglobin in the muscle cells (Aberle et al., 2001; Figure 5). Indications of advanced maturation can result in less desirable eating experiences in terms of tenderness and cooked meat flavor, in addition to poor lean color presentation. Tenderness affected by physiological maturation is caused by the progressively increasing amount of cross-linking bonds in the collagen surrounding muscle bundles and fibers. This cross-linking results in a more heat-stable structure, thus cooked meat from older animals tends to be less tender than meat from younger animals (Warris, 2010). Lawrence et al. (2001) described a positive correlation between WBSF increases and advances in beef carcass lean maturity. Further, Smith et al. (1982) found incremental decreases in flavor desirability as carcass maturity advanced.

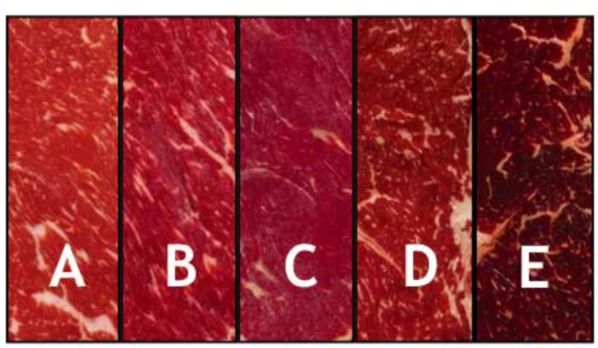

Figure 5. Examples of lean color requirements for the respective USDA beef maturity classifications

Meat color is very important to consumers when purchasing fresh cuts (Seideman et al., 1984; Mancini and Hunt, 2005). Early on, Allen (1968) proposed that the ideal color of beef is a "cherry red" color; Jeremiah et al. (1972) subsequently adjusted that claim to something slightly more pale than cherry red. A study conducted by Robbins et al. (2003) resulted in an understanding of consumers desiring a "moderately bright red" color. Regardless of the verbiage nuances, beef with a lighter color tends to be more desirable to consumers than that of a darker nature (Jeremiah et al., 1972). Fresh beef from carcasses derived from A-maturity cattle will have a lighter color appearance than beef from carcasses produced from older cattle (Aberle et al, 2001) resulting in a greater chance of consumer desirability.

Recent research indicates a potential to evaluate beef carcass maturity of known young grain-finished beef cattle using dentition in lieu of USDA skeletal maturity evaluation (Acheson et al., 2014; Tatum, 2015; Semler et al., 2016). Acheson et al. (2014) evaluated cattle with dentition indicative of cattle having less than 30 months of age (Figure 6); concomitantly, two age classes (A and B-C maturity) were established based on traditional USDA maturity evaluations of lean and skeletal assessment and subsequent carcass and palatability traits were tested between the treatments. Holding marbling constant, little to no differences were found with regards to palatability between the age class treatments. Furthermore, in a subsequent study conducted by Semler et al. (2016; A vs. B-D maturity) similar results were found to that of the Acheson et al. (2014) study. Both studies relied heavily on skeletal maturity weighting (most cattle had A maturity lean) for identifying carcasses for the more advanced maturity treatments, indicating skeletal maturity of young, grain-finished cattle may not be the most optimal identifier of maturity for graded beef. This recent evidence may suggest dentition as a more accurate determinant of maturity in cattle than the traditional physiological indicator of skeletal structures in relation to beef palatability, and should be further evaluated in the future as a means of ultimate carcass palatability determination.

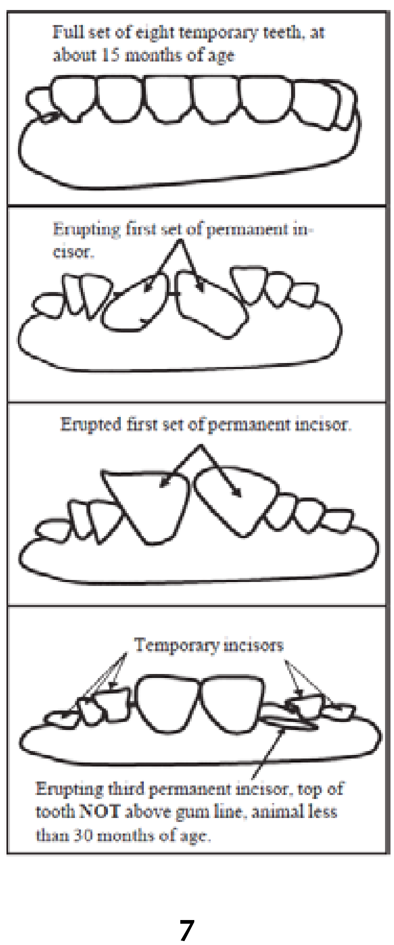

Figure 6. Examples of identifying approximate physiological age of cattle based on dentition (USDA, 2004)

Carcass Sizing Consistency Specifications: Hot Carcass Weight no Greater than 1,050 lb., Ribeye Area of 10 to 16 Square Inches, and Fat Thickness Less than 1 Inch

Hot carcass weight of the beef carcass has historically been associated (moderate correlation; Table 3) with predicting its approximate retail meat yield of cuts (Epley, 1970), and has long been used as a variable in the calculation of the USDA Yield Grade for a beef carcass (USDA 1997). In 2007 and again in 2014, the CAB brand made adjustments to the carcass specifications to include a measurement of hot carcass weight. Currently, the specification requires hot carcasses qualifying for the brand to be no more than 1,050 lb., which was based on research conducted internally at Certified Angus Beef LLC to guarantee consistency of subprimals from qualifying carcasses. The initial hot carcass weight specification of less than 1,000 lb. was established in 2007 and was retained until 2014, when a reevaluation of the carcass weight specification changed the maximum weight to qualify for the brand to 1,050 lb. or less. Assuming the general acceptance of mean subprimal weights from carcasses using the original hot carcass weight specification, the adjustment in 2014 had a negligible effect on mean subprimal weights (less than 0.5 lb.) holding all other carcass specifications constant (internal research results).

Table 3. Simple correlation (r) of subprimal weight by hot carcass weight*

Cut	r, HCW (lb.) vs. Subprimal Wt. (lb.)
Bottom Round Flat	0.83
Brisket	0.82
Chuck Roll	0.70
Clod	0.86
Knuckle	0.80
Ribeye, boneless, lip-on	0.86
Eye of Round	0.74
Striploin, boneless, 0x1	0.79
Tenderloin, PSMO	0.75
Top Butt	0.81
Top Round	0.83

* Research conducted internally at Certified Angus Beef LLC.

The ribeye area specification of 10 to 16 square inches for CAB-qualifying carcasses helps to maintain consistency primarily of middle-meat dimensional sizing (Figure 7), in addition to being somewhat of a predictor of end-meat weights (Bass et al., 2008). Dunn et al. (2000) identified the ideal ribeye area for foodservice at between 12 and 15 square inches when trying to optimize tenderness, consistency, and cooking

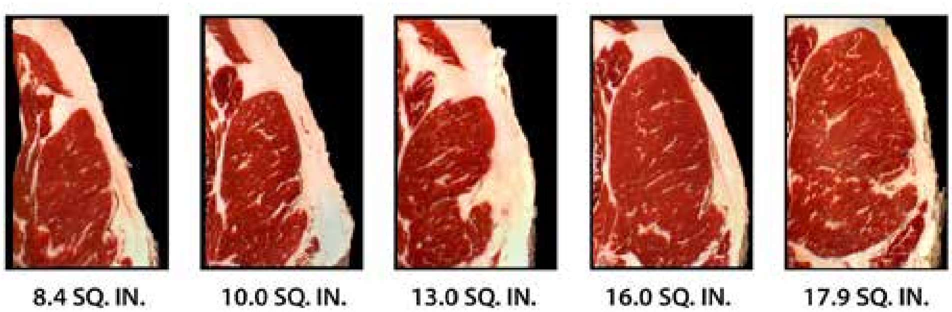

Figure 7. Examples of varying beef ribeye areas.

The size range of 10 to 16 square inches of ribeye area was determined by the CAB team to be within an acceptable range for middle-meat dimension consistency, while allowing an acceptable number of carcasses into the program and preventing excessively large or excessively small ribeye areas from qualifying for the brand, thereby producing more consistent middle meats. A narrow range for carcass ribeye area provides more ideal thickness when middle-meat items such as ribeye and striploin cuts are portioned, allowing for more control in cooking to the preferential degree of doneness. Since meat is sold by weight, a too-large ribeye dimension would need to be cut to a thinner thickness to obtain a certain portion (ounce) size when compared to a CAB middle-meat item cut to the same portion size. Concomitantly, a ribeye of too small surface area size would need to be cut to too thick and result in an inconsistent appearance when compared to those cut from CAB middle-meat items. Research funded by the beef checkoff and conducted at Colorado State University identified the density of the LL and thereby allowed approximate calculation of the thickness of a center-cut striploin steak cut to a specific weight (Bass et al, 2008). Results of the investigation found that a 10 oz. center-cut striploin steak with the tail removed coming from a striploin with a surface area between 10 to 16 square inches would almost always allow for a steak cut to between 1.0 and 1.5 inches thick (Table 4). Furthermore, if ribeye area is maintained within precise parameters (i.e., 10 to 16 sq. in.) but the weight of the subprimal increases with increasing carcass weights, the additional weight would result in a longer cut of meat.

Table 4. Estimated steak thickness cut to a specific weight based on the size of the ribeye area*

Steak Size oz.	10	12	14	16	18
REA sq. in.					
7	2.18	2.62	3.06	3.49	3.93
8	1.91	2.29	2.67	3.06	3.44
9	1.70	2.04	2.38	2.72	3.06
10	1.53	1.83	2.14	2.45	2.75
11	1.39	1.67	1.95	2.22	2.50
12	1.27	1.53	1.78	2.04	2.29
13	1.18	1.41	1.65	1.88	2.12
14	1.09	1.31	1.53	1.75	1.96
15	1.02	1.22	1.43	1.63	1.83
16	0.96	1.15	1.34	1.53	1.72
17	0.90	1.08	1.26	1.44	1.62
18	0.85	1.02	1.19	1.36	1.53
19	0.80	0.97	1.13	1.29	1.45
20	0.76	0.92	1.07	1.22	1.38

* Based on a muscle density of 1.132 g/cm3

Excessively fat cattle (Figure 8) are eliminated from the CAB program by the carcass specification requiring less than 1 inch of external backfat when measured at the outside surface of the ribeye three-fourths of the length of the ribeye muscle from its chine bone. One inch of backfat is the equivalent of a preliminary USDA yield grade of 4.5 (AMSA, 2001); therefore the CAB backfat thickness specification quickly eliminates the poorest yielding carcasses from entering the program. The use of carcass fatness was evaluated and established in the USDA yield grade formula in the 1960s (Murphey et al., 1960) and has long been a measurement contributing to a reasonable estimate for the yield of boneless, closely trimmed retail cuts produced from a beef carcass. By maintaining a maximum backfat thickness specification, CAB-licensed packers can send a more accurate signal through their value-based procurement to the producer who raises excessively fat cattle. This practice encourages high-quality, high-yielding beef for the end user. Moreover, by limiting the amount of "waste" fat, processors are able to better mitigate cost of the final product to the end user.

Figure 8. Excessive backfat thickness over the ribeye surface at the 12th and 13th rib interface.

Neck Hump not Exceeding 2 Inches

Crossbreeding of *Bos indicus* and *Bos taurus* has been a common practice in the United States for many years and is used to produce cattle more adapted to the high-temperature, subtropical environments found in the Southeastern United States (Thrift and Thrift, 2002; Highfill et al., 2012; Gama et al., 2013); *Bos indicus* cattle tend to endure heat-stress conditions better than *Bos taurus*, or European breeds, and thus have less pronounced physiological impact when subjected to those environments (Riley et al, 2005). However, along with *Bos indicus* cattle heat tolerance, there has been observed a greater propensity toward less tender meat harvested from those animals when compared to *Bos taurus*. While Thrift and Thrift (2002) compiled a review demonstrating the negative impact of *Bos indicus* breed influence on beef tenderness, more recently a study evaluating Angus cattle and various combinations of *Bos indicus* crosses with Angus cattle found that as the percentage of *Bos indicus* genetics increased in the cross, the less tender the meat from those animals (Elzo et al., 2012; Figure 9). As most studies evaluate only the LM for tenderness, Highfill et al. (2012) investigated 10 muscles of the beef carcass, including the LM, and confirmed the reduced tenderness effect of the *Bos indicus* genetics on other cuts of meat when compared to the same cuts derived from *Bos taurus* cattle.

Neck hump height is the physiological indicator on the beef carcass of whether it is of *Bos indicus* origin. Neck hump height is measured as an imaginary line drawn down the backline of the carcass from the dorsal edge of the *Ligamentum nuchae* to the maximum dorsal protrusion of the *Rhomboideus* muscle (Wulf and Page, 2000); this measurement must not exceed 2 inches (Figure 10) to be accepted into the CAB brand.

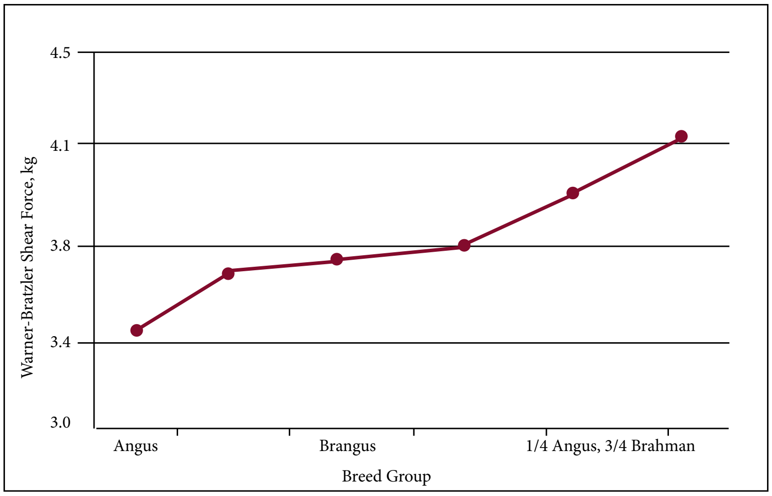

Figure 9. Warner-Bratzler shear force means for steers ranging in breed composition from 100% Angus to 100% Brahman. (Elzo et al., 2012)

Figure 10. Neck hump height measured as an imaginary line drawn down the backline of the carcass from the dorsal edge of the *Ligamentum nuchae* to the maximum dorsal protrusion of the *Rhomboideus* muscle must not exceed 2 inches.

Beef from *Bos indicus* genetics have tenderness challenges as the cattle tend to have a higher proportion of calpastatin in their system compared to *Bos taurus* (O'Connor et al., 1997; Ferguson et al., 2000). Calpastatin is the inhibitory enzyme of the primary proteolytic tenderizing enzyme, calpain (Dransfield, 1993). Calpain is a calcium-activated protease enzyme that weakens the structural myofibrillar proteins in the muscle which results in tenderization (Koohmaraie, 1994; Huff-Longergen and Lonergan, 1999). Calpastatin binds to calpains and prevents the calpains from continuing their proteolytic activity (Dransfield, 1993; Wendt et al., 2004; Melloni et al., 2006). Calpains are essential for enhancing tenderness while aging beef. With the *Bos indicus* cattle innately inhibiting the aging process because of the higher amounts of calpastatin naturally occurring in their system, it remains imperative that CAB restricts their influence in the program.

Moderately Thick or Thicker Muscling

Beef carcasses with more convex muscle conformation produce more meat than those with more concave muscling, typically commanding a higher value in most markets (Diez et al., 2006). Beef carcasses that meet CAB brand criteria must demonstrate superior muscling characteristics. This specification guarantees meat from a CAB carcass will have a greater muscle-to-bone ratio and a more desirable and consistent appearance. Furthermore, the superior muscling specification ensures the rejection of cattle exhibiting dairy-type muscle conformation; this criteria is especially critical for high-dollar cuts containing the ribeye or LD muscle. Compared to traditional beef breeds, dairy-influenced cattle consistently have smaller, narrow, elongated ribeyes, which is a common concern (Garcia-de-Siles et al., 1977; Knapp et al., 1989; Perry et al., 1991; Bass et al., 2009). Because of the narrow muscling and smaller plate coverage, in addition to lacking the appearance of a traditional beef steak, the middle meats from Holstein steer carcasses tend to lack in desirability among foodservice professionals (Lundeen, 2008).

Practically Free of Capillary Ruptures

Capillary rupture (Figure 11), also known as "blood splash," is the manifestation at the ribeye or other muscle surface where a pooling of blood spots is observed. Although it does not usually affect palatability, capillary rupture is aesthetically unappealing in the fresh state to the eye of a consumer, and thus is a disqualifying characteristic for the CAB brand.

Capillary rupture is believed to be caused by a number of conditions during the slaughtering process. The primary method of stunning in North America is done mechanically, utilizing a captive bolt in most cases to render the animal unconscious prior to exsanguination, or bleeding. The stunning process causes an increase in blood pressure; therefore if too much time passes prior to bleeding, the stunned animal has greater potential of rupturing the thin-walled capillaries in the muscle (Charles, 1960). Along with the physiological increase in blood pressure following stunning, the squeezing of veins due to uncoordinated muscle movement during stunning could increase the potential for rupturing the venules in the capillary bed where the blood vessels are the weakest (Gregory, 2005). Furthermore, animals that are properly handled, less excited upon stunning, and thus having a lower basal blood pressure at stunning could help to additionally prevent the ecchymosis (blood splash) condition (Mpamhanga and Wotton, 2015). This demonstrates how it is critical to both minimize handling stress and to efficiently and effectively bleed the animal as quickly as possible after stunning to prevent capillary rupture.

With the focus on visual appeal for consumers selecting a cut of beef, it is imperative that the product have extraordinary aesthetics; therefore, while rare, capillary rupture that detracts from product appearance must be prohibited from the CAB brand.

Figure 11. Example of internal hemorrhaging (capillary rupture) of the ribeye muscle at the 12 and 13th rib interface.

No Dark Cutting Carcasses

Normal pH for beef has been established at between 5.40 and 5.79 (Lawrie, 1958; Tarrant and Mothersill, 1977, Zhang et al., 2005). A-maturity beef with a pH found in the normal range will exhibit the consistently bright, moderately red coloring associated with desirable fresh beef. Dark-cutting beef can vary in color from barely evident to nearly black (USDA, 1997). The dark-cutting condition (Figure 12), at any level, is not allowed in carcasses destined for the CAB brand and thus are restricted from the program at the point of USDA certification.

The dark-cutting condition is believed to be a result of diminished amounts of the muscle sugar glycogen prior to harvest. Upon exsanguination during the harvesting process, the muscle cells no longer have blood to bring oxygen for aerobic metabolism of energy, thus the muscle cells proceed to anaerobically metabolize the muscle sugars available in an effort to continue producing energy until all resources are exhausted and cell death occurs. Anaerobic glycogen metabolism by the muscle cells produces a byproduct, lactic acid, which accumulates in the muscle and ultimately decreases pH (Seideman et al., 1984; Bender and Mayes, 2006). Cattle that have undergone a physical stressor will have an increased risk of meat quality defects (Ferguson and Warner, 2008). Stressors that contribute to the dark-cutting condition may include, but are not limited to: prolonged physiological stress prior to harvest, transportation stress, environmental and temperature changes, heifers in estrus, aggressive hormonal implant strategies, and mixing of cattle from differing social groups (Bass, 2009). Stress-induced depletion of glycogen reserves in muscle tissue has been implicated as the main cause of higher than normal pH in dark-cutting beef due to the lack of normal levels of lactic acid accumulation (Apple et al., 2005). Normal decreases of muscle pH after harvest is critical to achieving the desirable muscle color associated with fresh beef that is expected by consumers (Walters, 1975).

Figure 12. Example of a ribeye exhibiting the dark cutting condition.

Beef resulting in the dark-cutting condition has an unattractive and dry appearance, inhibitory to the merchandising of that fresh beef item (Aberle et al., 2001). As a result of the lack of desirable aesthetic appeal, depending on the severity of the condition, a dark-cutting beef carcass that otherwise would have qualified for a USDA Prime, Choice, or Select grade can be reduced by one full quality grade (USDA, 1997). Dark-cutting beef, because of its inherently high pH, will favor bacterial growth and allow for more rapid spoilage (Patterson and Gibbs, 1977).

In addition to the unappealing nature of the color of dark-cutting carcasses, the palatability of meat exhibiting this condition can be highly variable. Although meat with high ultimate pH exhibiting the visual characteristics of dark-cutting beef can be rather tender, meat that is showing a lesser degree of dark cutting can have severe tenderness issues. A higher pH can allow for more proteolytic enzyme activity; however, if the dark-cutting condition is only just beginning to manifest and the pH of the meat is between 5.8 and 6.0, then it will likely be much less tender than either meat of normal pH or that well within the range of dark cutting (>6.0 pH; Holdstock et al., 2014), believed to be a result of a pH range not conducive for effective proteolytic enzyme activity (Yu and Lee, 1986). In addition to the tenderness inconsistency of dark-cutting beef, the flavor can be highly variable as well. Dransfield (1981) and Holdstock et al. (2014) both confirm a lack of desirable beef flavor from dark-cutting beef. Additionally, Wulf et al. (2002) identified bitter and sour off-flavors in dark-cutting beef compared to normal beef.

Conclusion

All 10 carcass specifications, in addition to the live animal phenotypic identification, must be met in order for a beef carcass to qualify for the CAB brand. It is important that the brand continue to scientifically base all claims made on product quality, consistency, and appearance. Since beef can be highly variable, these specifications continue to sustain the CAB brand as a source of consistency in a demanding and competitive beef product community.

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