RESEARCH R&KM KNOWLEDGE MANAGEMENT

WHITE PAPER
Product Enhancement Research

Beef from Market Cows

Dale R. Woerner, Ph.D., Colorado State University

Introduction

For most beef and dairy producers, marketing culled cows translates to 15 to 25% of their annual income and clearly contributes to the profitability of their operation. In all production sectors, cows are routinely culled from operations as a result of decreased productively, efficiency and profitability. For years, cattle producers have been searching for ways to increase the profitability of their culled cows and have incorporated management decisions such as feeding culled cows prior to selling and holding cows until seasonality differences in the beef market favor increased market-cow prices (Figure 1). Regardless of what beef producers are doing or not doing to improve the profitability of culled cows, the vast majority of cows entering processing facilities result from live-auction markets, creating a tremendous amount of variation in the composition and quality of cows entering the beef market (Figure 2).

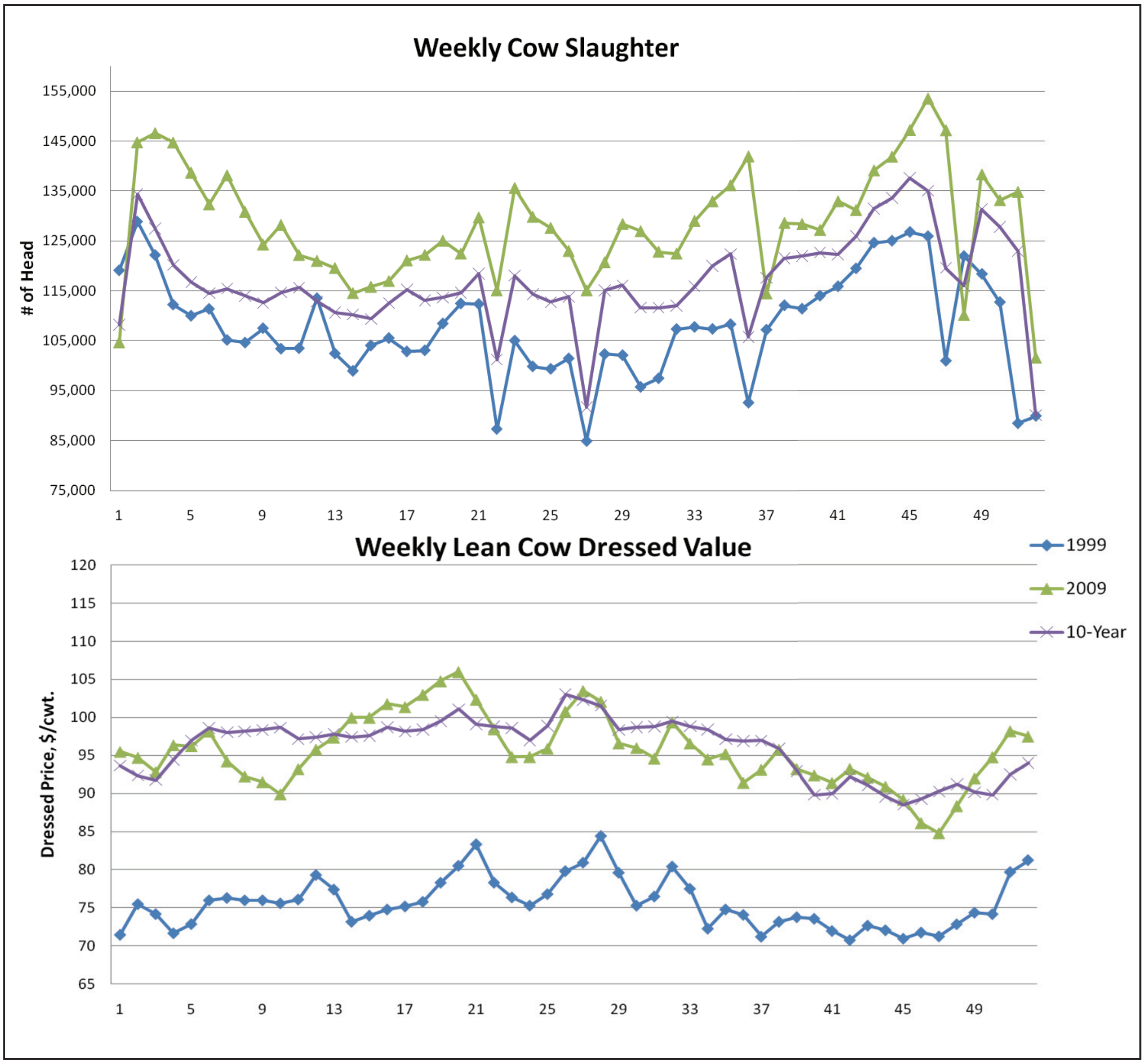

Figure 1. Weekly market cow slaughter and lean cow dressed value figures illustrating market tendencies and seasonal cow marketing (Source: USDA, AMS, Market News).

BEEF
Funded by
The Beef Checkoff

Figure 2. Cow, carcass, and ribeye images illustrating the amount of variation in live animal and carcass composition that exists in the market cow industry.

The cull-cow market comprises a significant portion of United States (U.S.) beef production. In fact, culled market cows, cows culled from cow-calf and seedstock producers as well as dairy operations, have consistently accounted for 17 to 19% of all cattle harvested in the U.S. each year. This equates to just over six million head and nearly 80,000 metric tons of boneless beef produced annually in over 55 major facilities. Most consumers believe that all cow beef ends up as ground beef and ultimately serves as the source for hamburgers in fast food restaurants. While the majority of boneless beef products produced from market cows is ultimately destined to be ground beef, nearly all facilities that are processing cows are producing whole-muscle cuts. These cuts include round cuts that serve as pure lean sources to upgrade conventionally produced ground beef, as well as rib, loin, round and chuck cuts that are merchandised as steak and roast items for foodservice applications. The most recent National Market Cow and Bull Audit (NCBA, 2007) indicated that 100% of audited facilities were producing rib and loin cuts and showed that an increasing number of companies were producing cuts from all primals. With the largest and most innovative packing companies that harvest market cows updating their facilities to accommodate the production of steak and roast items, the beef industry can expect to see an increased availability of "premium" cow products offered as lower-priced foodservice items destined for lower-end restaurants, buffets and cafeterias. Regardless of the price paid for these items and the cookery method employed, market-cow beef will have an increased influence on beef-eating experiences in the U.S. for years to come.

Classification of Market Cows

Primarily, as a result of chronological age and carcass maturity, the vast majority (> 85%) of culled market cows are not eligible for the traditional fed-beef United States Department of Agriculture (USDA) quality grades of Prime, Choice, Select and Standard. Cows that are greater than 42 months old are eligible for USDA carcass quality grades of Commercial, Utility, Cutter and Canner

(Figure 3). Even though some culled cows may qualify for youthful carcass quality grades and cow carcasses could be segregated by USDA quality grades for old beef animals in combination with USDA yield grades to estimate carcass composition and red-meat yield, USDA quality and yield grades do not reflect common trade practices for market cows. Therefore, USDA graders are not commonly employed to apply quality or yield grades to cow carcasses. Instead, market cows are commonly procured based on body condition scores (BCS; primarily a measure of live animal fatness) and are projected by cow buyers to fit into one of four carcass classifications. The four carcass classifications are described as follows (descriptions taken from Peel and Doye, 2008):

- **Breakers (or Breaking Utility):** Cows with a BCS of 7 or higher and a yield grade range of 2 to 4 (estimated red meat yield of 75 to 80%) that show considerable muscling; processed into various cuts
- **Boners (or Boning Utility):** Cows with a BCS of 5 to 7 and an estimated red meat yield of 80 to 85%; normally boned for processing beef after removal of merchandisable cuts
- **Lean:** Cows with a BCS of 1 to 4 and an estimated red-meat yield of 85 to 90%; will yield at most a few merchandisable cuts with the majority of the carcass used for boneless processing beef
- **Light:** Cows that may vary in estimated red meat-yield from 75 to 90%; always produce fewer pounds of boneless beef because the animal is small in overall size and weight, very light muscled and/or extremely thin in fleshiness.

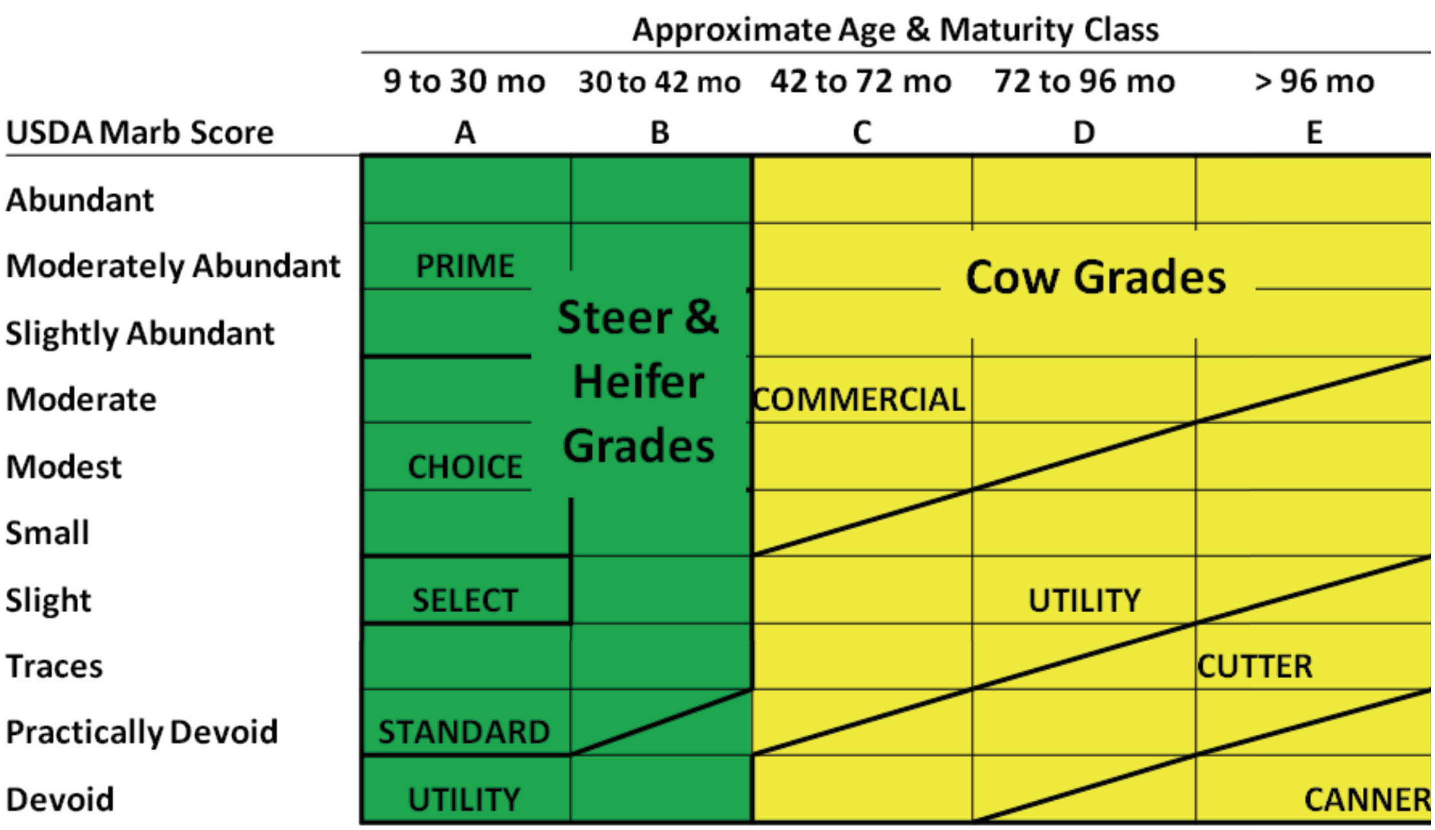

Figure 3. Marbling and maturity relationships to determine USDA quality grades.

A table constructed by Peel and Doye (2008) is presented to illustrate the relationship between BCS, market classifications and carcass characteristics for young beef cows (Table 1).

Table 1. Approximate associations between cull-cow marketing classification, carcass quality grade, and cow body condition score for young cows (Source: Peel and Doye, 2008).

Marketing Class	Red Meat Yield %	Dressing Percentage	Approximate Carcass Quality Grade*	Body Condition Score
Breaker	75 – 80	High	Commercial	8 – 9
		Average	Commercial	8
		Low	Commercial/Utility	7 – 8
Boner	80 – 85	High	Utility	6 – 7
		Average	Utility	6
		Low	Utility	5.5 – 6
Lean	85 - 90	High	Utility/Cutter	4.5 – 5.5
		Average	Cutter	4 – 4.5
		Low	Cutter	3 – 4
Light	75 – 90	High	Cutter	2 – 3
	Average	Cutter/Canner	2	
	Low	Canner	1 – 2	

**Quality grade depends on maturity. Grades presented in the table are approximately correct for young cows ("C" carcass maturity; 42 – 72 mo of age) and would likely be lower for older cows.*

Without the use of USDA grading personnel in the majority of cow plants, cow carcasses are commonly sorted by company personnel based on perceived carcass quality characteristics. Sorting decisions are most routinely based on the evaluation of carcass traits that indicate the level of feeding that cows have received prior to slaughter including fat color, lean color, amount of muscling and degree of marbling. Cows that have received a high-energy diet for an extended period of time prior to harvest tend to have lighter- or whiter-colored external and intramuscular fat, and also tend to have lighter, more youthful lean color scores, higher levels of intramuscular fat or marbling, a greater degree of external fatness and a greater amount of muscling. In contrast, cows that have received a lower plane of nutrition (primarily forage-based) produce carcasses with more yellowish-orange colored fat, darker, less desirable lean color scores, lower levels of marbling and lesser amounts of muscling. Generally speaking, animals that have received a high-energy diet prior to slaughter are obviously different in appearance and are easily identified in a carcass cooler that contains non-fed carcasses. It has been well documented that this type of cow produces higher quality muscle cuts with greater palatability ratings and increased consumer acceptance of steak and roast items. This type of cow is known in the industry as a "white-fat" cow, which almost always demands a premium from packers. Packers sell white-fat middle meats and other whole-muscle cuts to foodservice companies who commonly have implemented their own specifications and/or standards for fat and lean color scores.

Palatability of Beef from Market Cows

Beef palatability has been unanimously defined by tenderness, juiciness and flavor. The majority of market-cow beef presents challenges to the consumer's palate. When compared to conventionally produced beef resulting from grain-finished steers and heifers, the lion's share of beef produced from market cows is tougher, leaner and less juicy and has an increased prevalence of undesirable flavors. As a result, the majority of market-cow beef is merchandised as a ground-beef product that has commonly been blended with fat trimmings from conventionally produced steers and heifers or fat trimmings from fed (white-fat) cows. However, as mentioned previously, processors are utilizing ways to improve the palatability of cow products and are marketing higher-quality, whole-muscle cuts at a premium.

Factors influencing tenderness

The most significant factor adversely influencing the tenderness of market cow beef is animal age at the time of harvest. For over 30 years, it has been well documented that advancements in physiological maturity of beef carcasses are detrimental, particularly from the standpoint of tenderness (Romans et al., 1965; Walter et al., 1968; Berry et al., 1974). Many studies have explained that the amount of heat-labile (soluble) collagen in beef muscle decreases as the animal matures and is responsible for age-associated toughening (Goll et al., 1964; Hill, 1966; Herring et al., 1967). Decreased tenderness in whole-muscle cuts resulting from mature cows has been linked to elevated levels of insoluble intramuscular collagen (Boleman et al., 1996; Cranwell et al., 1996b; Schnell et al., 1997). With the vast majority of cows receiving a maintenance diet for their entire reproductive life, collagen tissue matures and gradually stabilizes to an insoluble, heat-resistant form causing a reduction in the amount of collagen that may be solubilized during subsequent cooking. Realimentation, or feeding cows at a level that exceeds maintenance requirements, causes increased protein synthesis and the turnover of collagen and is the most successful production tool to increase collagen solubility in mature cows.

Considering that a large percentage of cows harvested have minimal fat covering and are relatively small in size and mass, specifically non-fed market cows, cold shortening is another factor that can adversely impact the tenderness of cow products. Cold shortening occurs when muscle is chilled too rapidly following harvest and results in muscle fiber shortening and extreme toughening. Due to the absence of fat on the exterior of muscles, lean cows are especially susceptible to the effects of cold shortening. The exterior fat on fed and heavier-conditioned cull cows provides an insulating effect to protect muscles from the effects of cold shortening. To complicate things further, due to elevated concerns in regard to food safety issues in ground beef, most cow-harvest facilities chill carcasses very rapidly and utilize very low cooler temperatures which contribute to the incidence of cold shortening.

In addition to feeding cows, other post-harvest management practices have been shown to be effective to improve the tenderness of beef resulting from market cows. Postmortem aging has been widely accepted as an effective means of improving the tenderness of beef from steers and heifers (Gruber et al., 2006) and has also been shown to improve the tenderness of market-cow beef (Diles et al., 1994 and Woerner, 2009). The shear force (SF) values of the *longissimus* (LM) muscle of cow beef have been shown to rapidly decrease between 14 and 21 days postmortem, stabilize between 21 and 28 days, and then decrease again between 28 and 35 days postmortem (Woerner, 2009; Figure 4). Woerner (2009) provided evidence that the LM of cows aged differently than those from youthful beef animals (youthful beef muscle aged in a more linear fashion), and concluded that initial tenderness improvement resulted from improved myofibrillar tenderness and secondary tenderness improvement resulted from the ability of aging to degrade intramuscular collagen. High-voltage electrical stimulation also has been shown to improve the tenderness of market-cow beef (McKeith et al., 1980 and Boleman et al., 1996) and has been shown to increase the frequency of cow LM steaks that are acceptable in tenderness to consumers (Boleman et al., 1996). Additionally, calcium chloride injection has been show to effectively increase the tenderness and palatability ratings of cow beef (Morgan et al., 1991 and Diles et al., 1994).

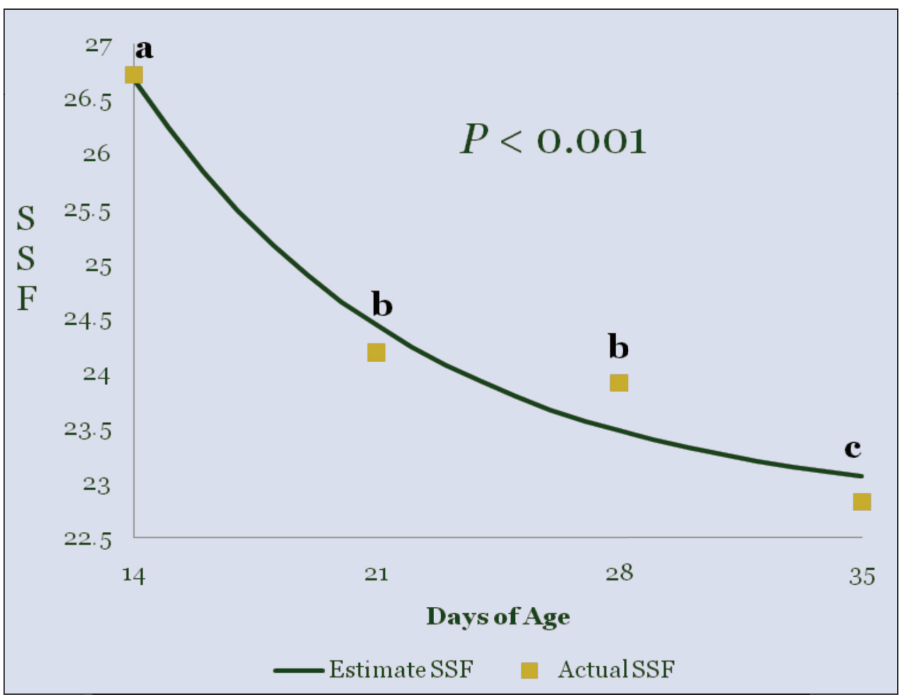

Figure 4. Slice shear force (SSF) values (kg) of the LM resulting from market cows at 14, 21, 28 and 35 days postmortem (Source: Woerner, 2009).

Factors influencing flavor desirability

The two major factors that influence the flavor of beef from market cows are animal diet and animal age. U.S. consumers prefer the flavor of beef products produced from grain-finished, youthful animals. On the contrary, the vast majority of U.S. consumers find that the flavor of grass-finished, mature beef is less desirable. Multiple studies have shown that beef from cattle finished on low-energy diets with high-forage contents has undesirable flavor (Brown et al., 1979; Schroeder et al., 1980; Dolezal et al., 1982; Melton et al., 1982; Hedrick et al., 1983; Larick et al., 1987), and Smith et al. (1983) showed that as maturity increases, flavor desirability decreases. These findings help explain why consumers find beef from market cows to be less desirable.

Bruce et al. (2005) reported that more than 40% of the variation in beef flavor between grass- and grain-finished beef is accounted for by diet. The diet of the ruminant animal is known to influence the composition of fat in the meat. In market cows, fat color serves as an excellent indication of the level of grain feeding that an animal has received prior to harvest (Schnell et al., 1997; Stelzleni et al., 2007; Woerner, 2009). Therefore, market cows are commonly segregated using fat color as an indication of quality and value. Concentrate feeding of cattle is generally associated with white carcass fat color (white fat), whereas grass-finishing is generally associated with yellow carcass fat color (yellow fat). While fat color (yellowness) is dependent upon multiple intrinsic and extrinsic variables including biological type, breed type and chronological age, animals that have regularly consumed a diet consisting primarily of forages produce carcass fat with increased yellowness. This yellowness is predominantly caused by chemical compounds in forages known as carotenoids. Carotenoids produce distinctively yellow and orange colors in beef fat. Beta-carotene is the primary pigment responsible for the development of yellow fat color in beef (Dunne et al., 2008). Specifically, as fat color transitions from white to yellow or orange, the incidence of consumer dislike and off-flavors increases (Hilton et al., 1998; Hodgson et al., 1992; Stelzleni et al., 2007; Woerner, 2009).

Feeding market cows a high-energy, grain-based diet for an extended period prior to harvest, and consequently transitioning fat color from yellow to white, is an effective means of reducing the incidence of off-flavors in cow beef and thereby improving overall palatability (Hilton et al., 1998; Hodgson et al., 1992; Stelzleni et al., 2007; Woerner, 2009).

Feeding Market Cows

Feeding beef-type cows

Aggressively feeding high-energy, high-concentrate diets to culled market cows prior to harvest is an effective means of increasing carcass fat content, increasing red-meat yield, increasing marbling, altering carcass fat composition and appearance (whiter fat), improving lean color and improving cooked meat palatability (Matulis et al., 1987; Boleman et al., 1996; Cranwell et al., 1996b; Schnell et al., 1997; Apple, 1999; Woerner, 2009). Sawyer et al. (2004) showed that feeding beef cows more conservatively (30% roughage diet for 54 days) resulted in 30% increases in cost of gain versus more aggressive feeding strategies (stepping cows up from a 30% to a 10% roughage diet in 10 days or a 20% roughage diet in 20 days and feeding them for a total of 54 days). Likewise, the most common industry practices for finishing cows towards white-fat premiums include aggressively feeding cows an 80 to 90% concentrate diet for 50 to 100 days prior to harvest. Studies have shown that the sharpest increases in feed efficiency (FE) and average daily gain (ADG) are noticed from 15 to 42 days on feed (Sawyer et al., 2004) and 29 to 56 days on feed (Matulis et al., 1987), while the lowest FE and ADG are encountered in the earliest and latest finishing periods. These differences in FE and ADG are explained by cows acclimating to a drastic change in diet in the early stages of feeding and the effects of compensatory gain dissipating in the later stages of feeding. At the same time, most studies agree that hot carcass weights (HCW), carcass muscling, lean color scores (brighter) and fat color scores (whiter) can all be significantly improved in the first 56 days of feeding (Matulis et al., 1987; Boleman et al., 1996; Cranwell et al., 1996b; Schnell et al., 1997). Additionally, two studies showed that feeding cows maximized the solubility of collagen in the LM in as little as 14 (Schnell et al., 1997) and 28 days (Cranwell et al., 1996b) on feed, and another study (Boleman et al., 1996) showed that collagen solubility tended to continually increase with time on feed up to 84 days. Consequently, Cranwell et al. (1996b) was able to link lower Warner-Bratzler shear force (WBSF) values and increased subjective tenderness ratings and sensory panel scores with increased collagen solubility. Without making a link to collagen solubility, Matulis et al. (1987) was also able to identify drastic improvements in LM tenderness for cows that had been fed a high-concentrate diet for 56 days. It may seem that feeding cows for 50 to 60 days is the answer to achieve significant carcass quality improvements and improvements in tenderness ratings while experiencing optimal FE and ADG. However, commercial cow packers commonly receive and process cows that have been fed high-concentrate diets for considerably longer periods of time.

Multiple studies (Cranwell et al., 1996b; Sawyer et al., 2004; Schnell et al., 1997) were not able to identify differences in marbling in cows that were not fed high-concentrate diets and cows that had been fed a high-concentrate diet for up to 56 days. Additionally, Schnell et al. (1997) was not able to identify differences in flavor attributes, including off-flavors, of the LM from cows fed high-concentrate diets from 0 to 56 days. However, studies that have evaluated carcass and palatability characteristics of cows fed more than 80 days have noted improvements in marbling levels as well as decreased SF values (Matulis et al., 1987; Boleman et al., 1996; Woerner, 2009) and increased sensory panel tenderness ratings (Boleman et al., 1996 and Woerner, 2009). To this point, commercial packers commonly finish cows using high-concentrate diets for a period of time that exceeds 80 days in order to achieve additional attributes including increased carcass fatness, increased marbling and decreased prevalence of off-flavors. In addition, feeding cows for an extended period provides an increased amount of white exterior fat, which is utilized by cow processing companies to meet customer specifications for ground beef that require higher fat percentages. Additionally, increased marbling levels and a decreased incidence of off-flavors found in cows fed for extended periods may contribute to a more satisfactory eating experience for consumers and higher demand in foodservice.

A recent study was conducted that included a large number of beef-type cows entering a large commercial processor (facility processes over 6,000 head per week) that had been aggressively fed with a high-concentrate diet for a 95 day (± 1 day) period (Woerner, 2009). This study revealed evidence that supports extended feeding periods to achieve definite differences in the composition of carcasses as well as lean and fat characteristics from fed, beef-type cows versus both non-fed beef cows and non-fed dairy cows entering the facility (Table 2). By feeding beef-type cows

Table 2. Least squares means comparing carcass characteristics of cattle in the sample population according to pre-harvest management strategy (Source: Woerner, 2009).

	Pre-harvest management[1]				
Item	**NON-FED**	**FED**	**DAIRY**	**SEM**	**P > FTRT**
Number of animals	104	108	113		
HCW, kg	251[c]	369[a]	311b	69	<0.001
Adj. fat thickness, cm	0.2[c]	1.3[a]	0.4[b]	0.05	<0.001
LM area, sq cm	56.1[c]	79.9[a]	64.6[b]	1.3	<0.001
Skeletal maturity score[2]	562[a]	566[a]	483[b]	8.7	<0.001
Lean maturity score[2]	540[a]	340[c]	445[b]	12	<0.001
Overall maturity score[2]	555[a]	463[b]	471[b]	9	<0.001
Marbling score[3]	215[b]	362[a]	385[a]	12	<0.001
LM intramuscular fat, %[4]	3.56[c]	7.02[a]	6.28[b]	0.26	<0.001
LM lean color score[5]	4.4[a]	3.5[b]	4.2[a]	0.1	<0.001
Fat color score[6]	5.3[a]	2.2[b]	2.1[b]	0.16	<0.001
LM SSF, kg[7]	28.27[a]	21.20[c]	23.75[b]	0.59	<0.001
LM collagen content, mg/g	5.09[a]	3.60[b]	4.64[a]	0.39	<0.001

[1] NON-FED = cows entering the slaughter facility as culls from sale barns and/or ranching operations; FED = cows entering the slaughter facility from a finishing yard having received a corn-based, high-energy diet for a 95 d ± 1 d period; DAIRY = cows entering the slaughter facility directly from dairies as culls.

[2] 100 to 199 = A00 to A99; 200 to 299 = B00 to B99; 300 to 399 = C00 to C99; 400 to 499 = D00 to D99; 500 to 599 = E00 to E99.

[3] 200 to 299 = Traces00 to Traces99; 300 to 399 = Slight00 to Slight99.

[4] % reported on a wet sample basis.

[5] 1 = light, pinkish-red, 2 = cherry red, and 6 = dark, purplish-red.

[6] 0 = bright white; 5 = pale yellow, and 8 = dark, yellowish-orange.

[7] SSF measurements were computed across postmortem aging period (14, 21, 28, and 35 d).

[a, b, c] Means in the same row without a common superscript differ ($P < 0.05$).

for an extended period, superior improvements in HCW, LM area, lean color scores (lean maturity and subjective lean color), LM collagen content and LM SF were observed for fed, beef-type cows when compared to both non-fed beef- and dairy-type cows (Woerner, 2009). Woerner (2009) also identified long-fed, beef-type cows as clearly having the greatest amount of external fat (adjusted fat thickness), which provides opportunities for packers to blend trimmings to ultimately increase the fat percentages of ground beef to more desirable levels. In agreement with the findings of Woerner (2009), although duration of feeding prior to harvest was not specified, Stelzleni et al. (2007) identified fed, beef-type cows entering a commercial packing facility as being superior to non-fed beef cows in identical and related carcass characteristics. Additionally, when compared to non-fed beef cows, Woerner (2009) identified that long-fed, beef-type cows also had decreased probabilities of grassy, liver/organy and fishy off-flavors, and found that long-fed cows had the highest probabilities of not possessing any off-flavors (Woerner, 2009).

It also should be noted that companies that are investing in intensive, high-concentrate feeding programs also are carefully selecting cows on an individual basis based on genetic type and live-body composition prior to making the decision to place them in a feeding regime. Woerner (2009) found that the sample population of cows that entered the processing facility following an extensive feeding period was comprised of over 94% British and Continental types of cows with the balance of cows having phenotypes expressing Brahman influence. On the contrary, over 25% of non-fed cows had phenotypes that indicated Brahman influence and the percentage of Continental-type was reduced by over 15% when compared to the fed-cow sample population. This indicates that producers and packers have a tendency to feed a higher percentage of Continental-type cows. This decision is likely based on Continental-type cows producing heavier weight carcasses and greater muscling scores than all other breed types (Woerner, 2009). Muscling, marbling scores, red-meat yield and carcass fatness were improved by feeding British-type cows. However, Woerner (2009) identified that feeding Brahman-type cows for an extended period results in improved marbling scores and increased external fat, but carcass muscling does not improve with HCW as a result of feeding. These data show advantages to feeding Continental-type and British-type cows, but minimal advantages to feeding Brahman-type cows.

Feeding dairy cows

Dairy cows make up about 30% of all market-cow slaughter, and the majority of dairy cows arrive at processing facilities as direct culls from dairies or via livestock auctions. Even though these cows are not commonly placed in confinement and fed high-concentrate diets for the purposes of fattening or improving quality to qualify for white-fat premiums, these cows clearly receive a higher plane of nutrition during their lifetime than the average non-fed, beef-type cow. As a result, while fed, beef-type cows have clear advantages in muscling and HCW, studies have shown that non-fed dairy cows produce beef products that are comparable in palatability attributes to beef products from fed or white-fat, beef-type cows (Stelzleni et al., 2007; Woerner, 2009). Studies have shown that non-fed dairy cows produce carcasses with fat color scores, flavor profiles (Woerner, 2009) and marbling scores (Stelzleni et al., 2007 and Woerner, 2009) that are similar to fed, beef-type cows. Additionally, Stelzleni et al. (2007) showed that LM SF scores and sensory panel ratings for tenderness were similar for non-fed dairy cows and fed, beef-type cows, while Woerner (2009) showed that non-fed dairy cows were slightly tougher than fed, beef-type cows. Both studies (Stelzleni et al., 2007; Woerner, 2009) agree that non-fed dairy cows were superior to non-fed beef cows for palatability traits. These findings indicate that culled dairy cows potentially could be marketed as premium cow beef products similarly to fed, beef-type cows without requiring additional resources and time on feed.

Two studies (Stelzleni et al., 2007; Allen et al., 2009) have made direct comparisons between non-fed and fed market dairy cows and both have identified advantages to feeding dairy cows prior to harvest. Improvement in HCW, marbling score and lean color or lean maturity score were noticed for dairy cows fed for an extended period prior to harvest versus cows that had been harvested as direct culls from dairies (Stelzleni et al., 2007; Allen et al., 2009). Additionally, a study that specifically evaluated the effects of feeding dairy cows noted that finishing cows on a high-energy diet for an extended period actually eliminated or reduced lameness problems (Allen et al., 2009). The authors of this study indicated that removing cows from the physical and physiological stresses of lactation and milking for an extended period was the primary reason for improvements in locomotion (Allen et al., 2009), while the 2007 Market Cow and Bull Audit noted that lameness attributed to increased trim loss, less saleable product and an increased likelihood of a cow becoming nonambulatory (NCBA, 2007). Nonetheless, Stelzleni et al. (2007) noted that despite improvements in carcass and LM characteristics for fed dairy cows versus non-fed dairy cows, WBSF and sensory panel ratings did not indicate differences in overall tenderness, beef flavor intensity nor the incidence of off-flavors between the two types of cows. Therefore, feeding dairy cows high-energy rations for an extended period prior to harvest is not as beneficial as feeding beef-type cows to improve muscle eating quality or sensory characteristics.

The Use of Growth Promotants

Growth-enhancement technologies are used as a management tool throughout the U.S. commercial cattle-feeding industry to increase weight gain, increase efficiency, increase product availability and decrease the per-unit cost of beef resulting from steers and heifers (NAHMS, 2000 and Lawrence and Ibarburu, 2007). In addition to receiving growth-promoting implants, an increasing number of cattle also receive diets that have been supplemented with one of two FDA-approved, beta-adrenergic agonists (beta-agonists; ractopamine hydrochloride or zilpaterol hydrochloride) during the final few weeks of finishing. While these technologies are clearly effective in young steers and heifers, research has indicated that the same technologies may not be as effective when used for finishing mature cows. With the lack of a clear understanding of the efficacy of all growth-promoting agents as well as the added cost of using growth promotants and the need to feed a high plane of nutrition for an extended period before the benefits can be realized, many producers are not utilizing these technologies to finish market cows.

Terminal implants have been shown to be the most effective growth-promoting technology to improve live weight gain, HCW, carcass muscling, REA and red-meat yield in mature cows that have been fed a high plane of nutrition (Cranwell et al., 1996a; Cranwell et al., 1996b; Funston et al., 2003). Beta-agonists have been shown to effectively improve feed efficiency, live weight gain, HCW, rib eye area (REA) and red-meat yield in young cattle (Gruber et al., 2007 and Vasconcelos et al., 2008); however, scientific findings indicate that there is minimal benefit to feeding mature cows the B-adrenergic agonist ractopamine hydrochloride (Dijkhuis et al., 2008 and Allen et al., 2009). Similarly, Neill et al. (2009) found that feeding mature cows a high-concentrate diet supplemented with zilpaterol hydrochloride did not improve carcass characteristics including HCW and REA. However, Neill et al. (2009) did find that feeding zilpaterol hydrochloride to cows that had received an implant that contained trenbolone acetate (TBA) resulted in increased REA and heavier subprimal weights when compared to fed cows that did not receive growth promotants and fed cows that had only received an implant. Therefore, combining implants and beta-agonists may be an effective means of increasing red-meat yields in mature cows.

In steers and heifers, growth promotants have been shown to have adverse affects on beef palatability ratings and tenderness (Platter et al., 2003; Gruber et al., 2008; Hilton et al., 2009). Interestingly, Cranwell et al. (1996b) discovered that steaks from implanted cows had more soluble (heat-labile) collagen, a higher percentage of soluble collagen and improved sensory characteristics of tenderness (myofibrillar and overall) and connective tissue amount. While steroidal implants increase the size and diameter of individual muscle fibers contributing to increased muscle toughness, they also increase the growth rate and simultaneously increase the rate of protein synthesis. Increasing protein synthesis in the mature animal also increases the proportion of newly synthesized collagen resulting in fewer intermolecular cross-links and less stable collagen fibers with higher solubility (McClain and Wiley, 1971). As discussed previously, increased collagen solubility results in increased tenderness. This indicates that utilizing steroidal implants may actually improve the tenderness of beef products resulting from fed, mature cows.

Summary

The cull cow market is a vital segment of the beef industry that provides a significant amount of ground beef and whole-muscle products to foodservice and retailer outlets. Non-fed market cows provide an abundance of lean beef, while fed, beef-type market cows (white-fat) and dairy cows add versatility by providing high-quality fat sources for improving ground beef as well as providing lower priced, high-quality, whole-muscle foodservice items. Feeding a high plane of nutrition to beef-type market cows is the most effective method to improve carcass red meat and fat yields as well as improving the overall quality and palatability attributes of market-cow beef. Steroidal implants have been shown to be an effective tool to improve fed-cow carcass traits, while additional, larger-scaled studies evaluating the use of beta-agonists in market cows are needed to develop a better understanding of their effectiveness in the cow industry. Postmortem aging and calcium chloride injection are effective post-harvest management tools to improve the tenderness and sensory characteristics of whole-muscle cow products.

References

Allen, J. D., J. K. Ahola, M. Chahine, J. I. Szasz, C. W. Hunt, C. S. Schneider, G. K. Murdoch, and R. A. Hill. 2009. Effect of pre-slaughter feeding and ractopamine hydrochloride supplementation on growth performance, carcass characteristics, and end product quality in market dairy cows. J. Anim. Sci. 87:2400-2408.

Apple, J. K. 1999. Influence of body condition score on live and carcass value of cull beef cows. J. Anim. Sci. 77:2610-2620.

Berry, B. W., G. C. Smith, and Z. L. Carpenter. 1974. Beef carcass maturity indicators and palatability attributes. J. Anim. Sci. 38:507-514.

Boleman, S. J., R. K. Miller, M. J. Buyck, H. R. Cross, and J. W. Savell. 1996. Influence of realimentation of mature cows on maturity, color, collagen solubility, and sensory characteristics. J. Anim. Sci. 74:2187-2194.

Brown, H. G., S. L. Melton, M. J. Riemann, and W. R. Backus. 1979. Effects of energy intake and feed source on chemical changes and flavor of ground beef during frozen storage. J. Anim. Sci. 48:338-347.

Bruce, H. L., S. L. Beilken, and P. Leppard. 2005. Textural descriptions of cooked steaks from bovine M. longissimus thoracis et lumborum from different production and aging regimes. J. Food Sci. 70:S309-316.

Cranwell, C. D., J. A. Unruh, J. R. Brethour, and D. D. Simms. 1996a. Influence of steroid implants and concentrate feeding on performance and carcass composition of cull beef cows. J. Anim. Sci. 74:1770-1776.

Cranwell, C. D., J. A. Unruh, J. R. Brethour, and D. D. Simms. 1996b. Influence of steroid implants and concentrate feeding on carcass and longissimus muscle sensory and collagen characteristics of cull beef cows. J. Anim. Sci. 74:1777-1783.

Dijkhuis, R. D., D. D. Johnson, and J. N. Carter. 2008. Case study: Feeding ractopamine hydrochloride to cull cows: effects on carcass composition, Warner-Bratzler shear force, and yield. Prof. Anim. Scientist. 24:634-638.

Diles, J. J. B., M. F. Miller, and B. L. Owen. 1994. Calcium chloride concentration, injection time, and aging period effects on tenderness, sensory, and retail color attributes of loin steaks from mature cows. J. Anim. Sci. 72:2017-2021.

Dolezal, H. G., G. C. Smith, B. W. Berry, and A. L. Carpenter. 1982. Comparison of subcutaneous fat thickness, marbling, and quality grade for predicting palatability of beef. J. Food. Sci. 47:397-401.

Dunne, P. G., F. J. Monahan, F. P. O'Mara, and A. P. Moloney. 2008. Colour of bovine subcutaneous adipose tissue: A review of contributory factors, associations with carcass and meat quality and its potential utility in authentication of dietary history. Meat Sci. 81:28-45.

Funston, R. N., J. A. Paterson, K. E. Williams, and A. J. Roberts. 2003. Effects of body composition, initial weight, and implant on feedlot and carcass characteristics of cull cows. Prof. Anim. Scientist. 19:233-238.

Goll, D. E., R. W. Bray, and W. G. Hoekstra. 1964. Age-associated changes in bovine muscle connective tissue. III. Rate of solubilization at 100 C. J. Food Sci. 29:622-628.

Gonzalez, J. M., J. N. Carter, D. D. Johnson, S. E. Ouellette, and S. E. Johnson. 2007. Effect of ractopamine-hydrochloride and trenbolone acetate on longissimus muscle fiber area, diameter, and satellite cell numbers in cull beef cows. J. Anim. Sci. 85:1893-1901.

Gruber, S. L., J. D. Tatum, J. A. Scanga, P. L. Chapman, G. C. Smith, and K. E. Belk. 2006. Effects of postmortem aging and USDA quality grade on Warner-Bratzler shear force values of seventeen individual beef muscles. J. Anim. Sci. 84:3387-3396.

Gruber, S. L., J. D. Tatum, T. E. Engle, M. A. Mitchell, S. B. Laudert, A. L. Schroeder, and W. J. Platter. 2007. Effects of ractopamine supplementation on growth performance and carcass characteristics of feedlot steers differing in biological type. J. Anim. Sci. 85:1809-1815.

Gruber, S. L., J. D. Tatum, T. E. Engle, K. J. Prusa, S. B. Laudert, A. L. Schroeder, and W. J. Platter. 2008. Effects of ractopamine supplementation and postmortem aging on longissimus muscle palatability of beef steers differing in biological type. J. Anim. Sci. 86:205-210.

Hedrick, H. B., J. A. Paterson, A. G. Matches, J. D. Thomas, R. E. Morrow, W. C. Stringer, and R. J. Lipsey. 1983. Carcass and palatability characteristics of beef produced on pasture, corn silage, and corn grain. J. Anim. Sci. 57:791-801.

Herring, H. K., R. G. Cassens, and E. J. Briskey. 1967. Factors affecting collagen solubility in bovine muscles. J. Food Sci. 32:534-538.

Hill, F. 1966. The solubility of intramuscular collagen in meat animals of various ages. J. Food Sci. 31:161-166.

Hilton, G. G., J. L. Montgomery, C. R. Krehbiel, D. A. Yates, J. P. Hutcheson, W. T. Nichols, M. N. Streeter, J. R. Blanton, Jr., and M. F. Miller. Effects of feeding zilpaterol hydrochloride with and without monensin and tylsoin on carcass cutability and meat palatability of beef steers. J. Anim. Sci. 87:1394-1406.

Larick, D. K., H. B. Hedrick, M. E. Bailey, J. E. Williams, D. L. Hancock, G. B Garner, and R. E. Marrow. 1987. Flavor constituents of beef as influenced by forage and grain feeding. J. Food Sci. 52:246-251.

Lawrence, J. D. and M. A. Ibarburu. 2007. Economic analysis of pharmaceutical technologies in modern beef production. Proc. NCCC-134 Conf. on Appl. Commodity Price Analysis, Forecasting, and Market Risk Management. Chicago, IL. Accessed April 28, 2010 at http://www.farmdoc.uiuc.edu/nccc134.

Matulis, R. J., F. K. McKeith, D. B. Faulkner, L. L. Berger, and P. George. 1987. Growth and carcass characteristics of cull cows after different times on feed. J. Anim. Sci. 65:669-674.

McClain, P. E. and E. R. Wiley. 1971. Influence of diet on metabolism and cross-linking in rat skin collagen. Fed. Proc. 30:402.

McKeith, F. K., G. C. Smith, J. W. Savell, T. R. Dutson, Z. L. Carpenter, and D. R. Hammons. 1980. Electrical stimulation of mature cow carcasses. J. Anim. Sci. 50:694-698.

Melton, S. L., M. Amiri, G. W. Davis, and W. R. Backus. 1982. Flavor and chemical characteristics of ground beef from grass, forage-grain, and grain-finished steers. J. Anim. Sci. 55:77-87.

Morgan, J. B., R. K. Miller, F. M. Mendez, D. S. Hale, and J. W. Savell. 1991. Using calcium chloride injection to improve tenderness of beef from mature cows. J. Anim. Sci. 69:4469-4476.

NAHMS. 2000. Feedlot 99 Part I. Baseline reference of feedlot management practices, 1999. USDA, APHIS, VS, CEAH, National Animal Health Monitoring System. Fort Collins, CO.

NCBA. 2007. Executive Summary of the 2007 National Market Cow and Bull Beef Quality Audit. National Cattlemen's Beef Association, Centennial, CO 80112. Funded by The Beef Checkoff.

Neill, S., J. A. Unruh, T. T. Marston, J. R. Jaeger, M. C. Hunt, and J. J. Higgins. 2009. Effects of implanting and feeding zilpaterol hydrochloride on performance, carcass characteristics, and subprimal beef yields of fed cows. J. Anim. Sci. 87:704-710.

Peel, D. S. and D. Doye. 2008. Oklahoma Cooperative Extension Service Fact Sheet: Cull Cow Grazing and Marketing Opportunities. Fact sheet AGEC-613. Accessed April 15, 2010 at http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-5148/AGEC-613web.pdf.

Platter, W. J., J. D. Tatum, K. E. Belk, P. L. Chapman, J. A. Scanga, and G. C. Smith. 2003. Effects of repetitive use of hormonal implants on beef carcass quality, tenderness, and consumer ratings of beef palatability. J. Anim. Sci. 81:984-996.

Romans, J. R., H. J. Tuma, and W. L. Tucker. 1965. Influence of carcass maturity and marbling on the physical and chemical characteristics of beef. I. Palatability, fiber diameter and proximate analysis. J. Anim. Sci. 24:681-685.

Sawyer, J. E., C. P. Mathis, and B. Davis. 2004. Effects of feeding strategy and age on live animal performance, carcass characteristics, and economics of short-term feeding programs for culled beef cows. J. Anim. Sci. 82:3646-3653.

Schnell, T. D., K. E. Belk, J. D. Tatum, R. K. Miller, and G. C. Smith. 1997. Performance, carcass, and palatability traits for cull cows fed high-energy concentrate diets for 0, 14, 28, 42, or 56 days. J. Anim. Sci. 75:1195-1202.

Schroeder, J. A., D. A. Cramer, R. A. Bowling, and C. W. Cook. 1980. Palatability, shelf-life, and chemical differences between forage and grain-finished beef. J. Anim. Sci. 40:852.

Smith, G. C., J. W. Savell, H. R. Cross, and Z. L. Carpenter. 1983. The relationship of USDA quality grade to beef flavor. Food Technology pp. 233-238.

Stelzleni, A. M., L. E. Patten, D. D. Johnson, C. R. Calkins, and B. L. Gwartney. 2007. Benchmarking carcass characteristics and muscles from commercially identified beef and dairy cull cow carcasses for Warner-Bratzler shear force and sensory attributes. J. Anim. Sci. 85:2631-2638.

Vasconcelos, J. T., R. J. Rathmann, R. R. Reuter, J. Leibovich, J. P. McMeniman, K. E. Hales, T. L. Covey, M. F. Miller, W. T. Nichols, and M. L. Galyean. 2008. Effects of duration of zilpaterol hydrochloride feeding and days on the finishing diet on feedlot cattle performance and carcass traits. J. Anim. Sci. 86:2005-2015.

Walter, M. J., D. E. Goll, E. A. Kline, L. P. Anderson, and A. F. Carlin. 1965. Effects of marbling and maturity on beef muscle characteristics. I. Objective measurements of tenderness and chemical properties. Food Tech. 19:841.

Woerner, D. R. 2009. Dissertation: Use of video image analysis to identify carcass characteristics and sensory quality of beef products generated from mature cow carcasses. Colorado State University Library, Fort Collins, CO 80523. Call number SF207.W647.2009.

For more information contact:

National Cattlemen's Beef Association

9110 E. Nichols Ave., Ste. 300
Centennial, CO 80112
303.694.0305 — 303.850.3348

7101