Forage-Finishing Beef: Impact on Consumer Appeal and Meat Quality

Carol L. Lorenzen. Ph.D.

Professor, Division of Animal Sciences, University of Missouri – Columbia

Introduction

The use of forage to replace grains in finishing diets of cattle has been discussed since cattle have been in feedlots. When reviewing the literature, it seems that there is a push to replace grains with alternative rations about every twenty years. Until the use of grains to make fuels, most of the rationale has centered on the use of lands to produce "feed" instead of "food." However, at the times that this topic has been raised in the past, the science and economics have dictated that the practice of finishing cattle on high energy, grain diets remain in place. The challenge that beef cattle industry is facing today is different than the challenges it has faced in the past and warrants revisiting the effects of high levels of forage inclusion in the diet has on meat quality. Additionally, the niche marketing efforts of some cattle producers to produce a forage-finished beef product have attracted major marketing avenues, such as Whole Foods and the USDA grass-fed standard make it more fashionable, if not more profitable, than in the past.

Table 1: Relationships[a] between feeding systems and meat quality attributes[b]

	Feeding Systems					
Trait	Rate of gain	Grazing	Feedlot days	Dietary protein	Dietary fat	Energy source
Producer/feedlot						
Carcass grading		Y				
Consumer/foodservice						
Lean color			N			
Lean texture		N				
Fat color		N			N	N
Fat melting point		N	N		N	N
Marbling	N	N	N		N	N
Tenderness	N		N			
Juiciness					N	
Flavor desirability		N	N		N	N
Flavor intensity		N	N	N	N	N
Acceptability			N			
Shelf life					N	

[a] Relationships: Y – indicates factor affects trait according to published literature; N – indicates factor does not affect trait according to published literature

[b] Adapted from Owens and Gardner, 1999.

Meat quality has different meanings to different segments of the beef cattle industry. For the producer/feedlot operator, meat quality relates to carcass characteristics, such as dressing percentage, and the USDA yield and quality grade traits. To the consumer /food-service operator, meat quality is defined as product attributes such as fat content, meat and fat color, and cooking yield. A summary of the effects of different feeding systems on meat quality traits is found in Table 1. Most of these columns reveal that the feeding systems do not affect meat quality when comparisons are made at the same body compositional endpoint. However, decreased grain in the finishing diet can alter the body composition at harvest and result in meat quality differences. This brief review will focus on areas where changes from a high grain diet can positively or negatively affect meat quality.

Nutritional Composition

Nutritional composition, an aspect of consumer satisfaction, changes with deviations in feeding regimes. Current nutritional labeling for meat requires calories, calories from fat, total fat, saturated fat, cholesterol, sodium, total carbohydrates, dietary fiber, sugars, protein and vitamins and minerals. Four of these categories specifically deal with the fat component. There are four distinct fat depots in cattle that are laid down during growth and development in the following order: perinephric (internal), subcutaneous (external), intermuscular (seam), and intramuscular (marbling). Marbling is fat of the highest value because it largely determines USDA quality grade and it is not deposited until the cattle have excess energy in their diet and their maintenance and growth needs have been met. Fat is made up of phospholipids and triglycerides. Triglycerides have three fatty acids attached to a glycerol back bone.

Fatty acids (FA) are either **saturated**, no double bonds within the chemical structure, or **unsaturated**, one or more double bonds within the chemical structure. Consuming large quantities of certain saturated FA has been implicated in heart disease. All animal fats are a mixture of saturated and unsaturated FA with ruminant animals having a higher percentage of saturated FA than monogastric animals. Many studies have reported the differences in FA composition between forage- and grain-finished cattle. FA composition affects the flavor of the meat, melting point of the fat, and fatty acid oxidation. One FA group that has gained a lot of attention is total conjugated linoleic acid (CLA) because of its potential role in human health reducing body fat and improving immune function. Total CLA content (isomers *cis-9, trans-11*; *trans-10, cis-12*; *cis-9, trans-11*; *trans-9, trans-11*) is increased in meat and milk products when cattle are fed substantial levels of forage (Table 2). Table 2 shows that even the inclusion of forage in the diet with a small supplementation of grain can increase the CLA content in both raw and cooked meat. Others have shown an increase in CLA content with forage-feeding (Jiang *et al*., 2010; Duckett *et al*., 2009; Leheska *et al*., 2008). Another group of FA that have been shown to have health benefits is omega-3, noted as n-3 in the table. Human research points out that the health benefits of the n-3s mainly come from fish and nut sources; however, beef does contribute to the total amount of n-3s in the diet. The data in Table 2 point to an increase in n-3 content (n-6 remains the same or drops) when forage is used to finish cattle which is supported by other researchers (Jiang *et a*l., 2010; Duckett *et al*., 2009; Leheska *et al*.,

2008). When marketing for forage-finished beef claims an increase in “good” fatty acids, it refers to CLA and n-3s.

Table 2: Effect of feeding regime on conjugated linoleic acid isomers (CLA) content (mg/g fat) and omega-6 to omega-3 ratio[1]

Fatty Acids	Feedlot	Pasture + Grain	Pasture
Raw			
Fat (%)	5.7[a]	3.7[b]	3.7[b]
n-6:n-3	53.67	16.71	10.42
Total CLA	6.10[b]	6.68[b]	9.95[a]
Cooked			
Fat (%)	8.1[a]	5.3[b]	4.6[b]
n-6:n-3	40.84[a]	12.29[b]	9.26[b]
Total CLA	3.97[b]	6.15[a]	7.36[a]

[1]Adapted from Lorenzen *et al*., 2007

[a, b] Means within a row lacking a common superscript differ ($P < 0.05$)

Fat location on the carcass causes changes to the ratio of monounsaturated to saturated fatty acids regardless of feeding regime (Kerth *et al*., 2015). Fatty acids composition also differs by cut and is largely, but not solely, related to different percentages of fat within different muscles in trimmed cuts of beef (Table 3) reflecting the importance of having specific cuts tested before making marketing claims.

Table 3: Effect of muscle on conjugated linoleic acid isomers (CLA) content (mg/g fat) and omega-6 to omega-3 ratio[1]

Fatty Acids	Ribeye[2]	Inside round[2]	Shoulder Clod[2]
Raw			
Fat (%)	4.2[b]	3.8[b]	5.3[a]
n-6:n-3	22.44	32.44	22.70
Total CLA	8.64	9.83	9.25
Cooked			
Fat (%)	7.2[a]	4.6[b]	6.4[b]
n-6:n-3	17.81[b]	26.80[a]	16.64[b]
Total CLA	6.60[b]	7.18[ab]	7.93[a]

[1]Adapted from Lorenzen *et al*., 2007

[2]Ribeye = *Longissimus lumborum*, Inside round = *Semimembranosus*, Clod = *Triceps brachii*

[ab] Means within a row lacking a common superscript differ ($P < 0.05$)

Cooking method and degree of doneness can affect nutritional value and are important considerations since that is the way meat is consumed. During cooking, the outside of the meat browns and there is a progressive loss of the red color internally due to changes in myoglobin, the pigment responsible for meat color. The browning on the surface and breakdown of protein components during cooking contribute to changes in flavors at

different degrees of doneness. In addition, collagen shrinkage and protein hardening are responsible for decreased tenderness at higher degrees of doneness, like well done. There are two major components of meat that are lost during the cooking process, water and fat, which can affect the perception of juiciness. Therefore, as the degree of doneness increases, moisture content decreases and fat and protein contents increase on a percentage basis (Smith *et al*., 2011; Alfaia *et al*., 2010). The change in composition during cooking also impacts the nutritional value of the meat. Cooking increases saturated and monounsaturated fatty acid content while decreasing polyunsaturated fatty acids (Alfaia *et al*., 2010). Tables 2 and 3 show that cooking elevated fat percentages and decreased n-6:n-3 ratios and total CLA on a mg/g of fat basis compared to raw samples. The decreases are partially explained by the increase in fat during cooking and the stability of CLA during thermal processes (Alfaia *et al*., 2010).

Fat and Meat Color

Consumers make meat purchasing decisions based on color. It is the only indicator that they have that meat is wholesome and of high eating quality. One of the main objections to finishing cattle on forage is the increase in yellow color of the fat and darker color of the muscle due to the consumption of carotenoid pigments (Kerth *et al*., 2007; Dunne *et al*., 2006). Both Leheska *et al*. (2008) and Kerth *et al*. (2007) reported increased yellowness of subcutaneous fat in cattle finished on pastures compared to those finished on concentrate diets. Research has addressed the question of how long a high concentrate diet would have to be fed to cattle that have received a high forage diet to reverse the negative effect on fat and lean color. Dunne *et al*. (2006) reported marked decrease in the yellow fat color with 28 days of feeding a concentrate diet, but they noted that the exact time to mitigate the effects of forage would be dependent on diet. It has been reported that generally, the exclusion of forage for 90 days before harvest is recommended to mitigate the effects of forage feeding on both fat and lean color (Miller, 2002).

In addition to the feeding regime, the chronological age of the cattle also plays a role in the color of the fat and lean and the amount of time it will take for the negative effects due to forage-feeding to be changed. It is well established that as cattle get older their lean gets coarser and darker and their fat becomes more yellow. This typically does not happen with cattle less than 30 months of age. Bidner *et al*. (1981) reported in cattle less than 30 months of age no difference in fat color between forage, forage supplemented with grain, and feedlot finishing diets. However, Bidner *et al*. (1981) did report darker lean color scores for forage finished cattle compared to feedlot finished cattle.

Carcass Grading

In experiments when cattle are fed for the same number of days but at different energy levels, the cattle fed at the higher energy level tend to have heavier carcasses and increased levels of fatness (Kerth *et al*., 2007; Cox *et al*., 2006; Sinclair *et al*., 2001; Camfield *et al*., 1997, Moody, 1976). This decrease in carcass fatness by lower energy or forage-based diets can be viewed positively regarding a decreased USDA yield grade. The increased energy level in the diet when fed for greater periods of time also leads to

increased USDA quality grade factors (Owens and Gardner, 1999; Camfield *et al*., 1997; Moody, 1976). Significant, acceptable differences (achieving a USDA Select grade) can be seen in as little as 60 days on a high energy diet (Camfield *et al*., 1997).

Table 4: Effects of feeding regimes on USDA grade traits

Trait	Feedlot	Pasture + Grain	Pasture
Cool Season Grass[1]			
Hot carcass weight (lbs.)	732[a]	619[b]	561[c]
Fat thickness (in)	.44[a]	.21[b]	.14[b]
Ribeye area (in^2)	12.0[a]	10.9[b]	10.3[b]
Kidney, pelvic & heart fat (%)	3.0[a]	2.3[b]	1.9[c]
USDA yield grade	3.2[a]	2.4[b]	2.1[b]
Marbling score	Small[68a]	Slight[60b]	Slight[11b]
USDA quality grade	Choice^{-a}	Select^{-b}	Select^{-b}
Ryegrass[2]			
Hot carcass weight (lbs.)	729[b]	767[a]	502[c]
Fat thickness (in)	.42[a]	.41[a]	.25[c]
Ribeye area (in2)	12.6[a]	12.8[a]	10.5[b]
Kidney, pelvic & heart fat (%)	2.3[a]	2.2[a]	1.5[b]
USDA yield grade	3.0[a]	2.9[a]	2.3[b]
Marbling score	Slight[99]	Slight[80]	Slight[51]
USDA quality grade	Select$^+$	Select$^+$	Select$^-$

[1]Adapted from Lorenzen *et al*., 2007
[2]Adapted from Kerth *et al.*, 2007
[a, b, c] Means within a row lacking a common superscript differ ($P < 0.05$)

In experiments when cattle are fed to same body compositional endpoint, meaningful biological differences in USDA yield and quality grade traits are not seen (Bowling *et al*., 1977). In general, it takes forage finished cattle more time on feed to reach the same body compositional endpoint as compared to cattle finished on a high energy concentrate ration (Lorenzen *et al*., 2007). Often the increased length of time to finish the cattle on forage also had a negative impact on the economics of finishing the cattle.

When cattle are fed a combination of diverse cool season grasses (Lorenzen *et al*., 2007) or ryegrass (Kerth *et al*., 2007) and grain, acceptable levels of USDA yield and quality grade traits are reported (Table 4). These data show that the benefit of leaner cattle can be combined with an acceptable USDA quality grade when cattle finished on pasture are supplemented with grain at 1.2% of their body weight. It could be argued that a Select$^-$ average quality grade is not optimum and supplementation higher than 1.2% of the body weight may achieve more desirable results.

Meat Palatability

Palatability is commonly described as tenderness, juiciness and flavor, all the things that lead to consumer acceptability of the meat. Of these three, tenderness has the greatest potential to control with feeding regime. Some researchers have found forage-finishing has a negative impact on instrumental measures of tenderness (Schroeder *et al*., 1980; Bowling *et al*., 1977). Others report no differences in tenderness due to feeding regime (Lorenzen *et al*., 2007; Sinclair *et al*., 2001; Bidner *et al*., 1981) Kerth *et al*. (2007). They, however, reported increased values for mechanical tenderness in strip loins but not in ribeyes; this is an interesting finding because both cuts come from the same muscle and highlight the tenderness gradient that runs through most muscles. It should also be noted that many studies, even if they find a difference in tenderness, do not report values that reach the threshold for meat to be considered tough (Kerth *et al*., 2007; Lorenzen *et al*., 2007); indicating that acceptably tender meat can be produced by finishing beef on pastures. Chronological age of the cattle used in the experiments that reported no differences in tenderness is difficult to discern from the literature, whereas the ages of the cattle used in three other experiments were less than 30 months. As cattle mature, they get tougher due to reduced collagen solubility. Feeding cattle high energy diets prior to harvesting has been shown to increase collagen solubility regardless of the cattle's age (Miller *et al*., 1983; Aberle *et al*., 1981). The greatest increase in tenderness is found when cattle are fed a high energy diet for a minimum of 70 days (Aberle *et al*., 1981).

Table 5: Trained panel ratings for ribeye steaks from cattle on different feeding regimes[1,a]

Attribute	Feedlot	Ryegrass Pasture + Grain	Ryegrass Pasture
Initial juiciness	6.17[b]	5.35[c]	5.73[c]
Sustained juiciness	5.75[b]	5.15[c]	5.38[bc]
Initial tenderness	6.17	5.52	5.05
Sustained tenderness	5.73	5.00	4.49
Flavor intensity	6.02[b]	5.48[c]	5.44[c]
Beef flavor	5.92[b]	5.54[c]	5.28[c]

[1]Adapted from Kerth *et al*., 2007

[a] Based on an 8-point hedonic scale with 1 = dislike dry, tough, bland and 8 = extremely juicy, tender, flavorful

[b, c] Means with a row lacking a common superscript differ ($P < 0.05$)

Flavor is another aspect of palatability that can be controlled by feeding regime but to a lesser extent than tenderness. Some studies have reported lower flavor ratings for cattle finished on forages (Tables 5 and 6; Kerth *et al*., 2007; Lorenzen *et al*., 2007; Cox *et al*., 2006; Schroeder *et al*., 1980), while other studies have detected no differences (Sinclair *et al*., 2001; Bidner *et al*., 1981). However, except for the study conducted by Schroeder *et al*. (1980), all the other ratings were within the acceptable range. Data presented in Table 5 indicate a greater amount of juiciness and flavor in meat from cattle finished on

grain. All scores were above 4.0 on an 8-point scale (Table 5), which indicates that all attributes were on the positive part of the scale for the trait. While the data presented in Table 6 indicate that cattle finished on pasture or pasture with grain supplementation have lower consumer panel ratings for overall like, liking of flavor, and liking of juiciness; mean scores were above 5 on a 9-point scale (Table 6) indicating that the consumers found the samples to be acceptable in all traits. In both tables samples were matched for marbling scores between feeding regimes to reduce the known effect of marbling score on trained and consumer panel ratings where higher marbling scores are preferred. In another aspect of consumer preference, Cox *et al*. (2006) asked consumers about their intent to purchase meat and reported 65.9% of consumers would purchase steaks from cattle finished on grain compared to 34.1% that would prefer steaks from cattle finished on forage. Kerth *et al*. (2007) reported that consumers not only ranked grain-finished steaks higher but also would pay more money for them.

Table 6: Consumer panel ratings for ribeye steaks from cattle on different feeding regimes[1,a]

Attribute	Feedlot	Cool Season Pasture + Grain	Cool Season Pasture
Overall like	6.5[b]	5.8[c]	5.8[c]
Liking of tenderness	6.3	6.1	5.8
Liking of flavor	6.4[b]	5.7[c]	5.7[c]
Liking of juiciness	6.5[b]	5.5[c]	5.7[c]

[1]Adapted from Lorenzen *et al*., 2007

[a] Based on a 9-point hedonic scale with 1 = dislike extremely and 9 = like extremely

[b, c] Means with a row lacking a common superscript differ ($P < 0.05$)

Recommendations

Forage-finished cattle have an improved nutritional profile and have expectable eating quality. Cattle finished on forage should be supplemented, which can still provide the nutritional marketing claims, for a minimum of 70 days to reduce negative effects of forage on fat color, promote tenderness associated with collagen turnover, and achieve a USDA quality grade acceptable to the current marketplace. In addition, cattle fed a forage diet supplemented with grain should be slaughtered at less than 30 months of age to help decrease the potential negative effects of fat color and decreased tenderness.

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