Introduction

Interest in finishing beef cattle on a grass or forage diet has been in and out of popularity since the origin of beef in the U.S. Because of the abundance of inexpensive grain and the very efficient gains that result from finishing on a grain diet, finishing cattle on forage has never gained any momentum in the U.S. The differences in product characteristics between grass- and forage-finished beef have furthered the case against forage-finished beef as Americans became accustomed to the eating traits of grain-fed beef.

With grain and fuel prices continuing to increase, the economic feasibility of finishing cattle on forage has begun to make business sense. The current structure of the beef industry places the finishing operations (feedlots) near the sources of grain (the mid- and southwestern U.S.) since it is more economical to transport cattle than grain. Abundant numbers of cow-calf pairs can be found in southeastern states where mild winters and plentiful moisture support the growth of large quantities of forage year-round. In fact Little (1985) reported that 50% of all mature cows are located in the Southeast.

In addition to the economics of finishing cattle, other factors also have stimulated the increased interest in forage-finished beef. Consumers of beef today are increasingly more informed with a wealth of information available on the internet. The result is that they are more aware of nutritional breakthroughs and current trends in healthy diets. Recent emphasis on the consumption of “good fats” including omega-3 fatty acids, CLA, mono-unsaturated fatty acids, and omega-6 to omega-3 fatty acid ratios, and elimination of other fats such as trans-fats have caused consumers to evaluate not only the total amount of fat, but also the type of fat in their diet.

Finally, advances in the genetics of both forages and animals have also had a positive impact on the feasibility of finishing cattle on forage. The ability to select animals based on their carcass traits and even the meat tenderness enhances the ability to produce cattle with high quality meat in forage-finished, or any other alternative production system. This along with forage cultivars that have been selected solely for grazing (e.g. winter annual ryegrass \( \text{Lolium multiflorum} \)) have resulted in improved gains and carcass traits.

So with more and more factors that are in favor of finishing cattle on forage, we must understand and evaluate the basic differences between forage-finished beef and traditional grain-finished beef. Although these differences have been widely documented over the past 50 years, the vast changes in economics, animals, feedstuffs, and consumers warrant a current look at these differences.

Carcass Characteristics

Carcass weights of forage-finished beef cattle are lower than those in grain-finished carcasses (Bennett et al., 1995; Mandell et al., 1998; and Schnell et al., 1997). This is likely caused by the lower energy levels in the forage diet resulting in less subcutaneous fat deposition and less weight over similar periods of time. Researchers have documented lower USDA yield grades in the forage-finished beef carcasses (Camfield et al., 1999 and McMillin et al., 1982 and 1984). Additionally, forage-finished beef carcasses tend to have a smaller longissimus area compared to grain-finished beef. This is not always the case, however, since there have been instances where the loin eye areas were similar between the two types of carcasses (Abdullah et al., 1979).

Beef Flavor

There has been conflicting data concerning the flavor acceptability of forage-finished beef. A large amount of research has indicated that forage-finished beef has a grassy or milky flavor that is sometimes described as an off-flavor or a more intense flavor (Smith et al., 1977; Xiong et al., 1996; Montgomery and Bidner, 1979). In a review of forage-based...
beef finishing systems (Griebenow et al., 1997), the distinguishing flavor of forage-finished beef is attributed to the beef fat. Compounds referred to as diterpenoids are responsible for the off-flavor source. These compounds are derived from the action of ruminal microorganisms as they break down chlorophyll. In this same review, the authors refer to the fact that one other explanation of the off flavor in forage-finished beef is the higher concentration of C18:3 unsaturated fatty acids.

Conversely, there has been research that indicates that there is no sensory flavor difference between forage-finished and grain-finished beef (French et al., 2000; Montgomery et al., 1982; Abdullah et al., 1979). There are several possible explanations for the different outcomes of the different studies concerning forage-finished beef. The amount of time on forage (Melton, 1990) and forage type (Body, 1974) can certainly play a major factor in the flavor development of the beef, specifically in the deposition of the flavorful fat. Body (1974) reported that the lipid portion of white clover was primarily linoleic (C18:2) and linolenic (C18:3) acids. Linolenic acid has also been found to be the major constituent of other forages including Kentucky 31 Fescue, orchardgrass and ladino clover (Melton et al., 1982). It was noted by Griebenow et al., (1997) that as these forages mature, the amount of lignin increases within the forage, and thus digestion time increases. With this occurring, the amount of time forage is exposed to the action of ruminal microorganisms is increased and hydrogenation of the unsaturated fatty acids can take place at a higher rate. Thus, more of these types of fats may be deposited on the animal.

Another major consideration in flavor evaluation of forage-finished beef is the inconsistencies within groups of taste panelists. Griebenow et al. (1997) reported that there appears to be a difference between trained panelists and untrained consumers in their ability to detect off-flavors in beef. The trained panelist more consistently detects the off-flavor in forage-finished beef than do the consumer panelists. Seeing as each study concerning forage-finished beef is essentially evaluated by completely different types of panels, it is certainly conceivable that there appears to be inconsistencies in the data. Certainly our own observations have found that the method of cookery, fat content, and cut all impact the grassy-type flavor with products having higher fat content, like ground beef, having a more pronounced grassy flavor.

The primary method to eliminate or reduce the amount of grassy flavor in beef has been to supplement the animal with low levels of concentrate. French et al. (2000) concluded that supplementing cattle with low levels of concentrate produced the most tender and acceptable meat at 2 days post mortem, but further aging eliminated all treatment effects on eating quality. Chen et al. (1984) reported that the addition of beef fat from grain-finished steers potentially improved the palatability of forage-finished beef and may be an acceptable alternative for increasing the utilization of beef from forage-finished animals. Other methods of post harvest treatment have also been explored. Robbins et al. (2003) found that pumping forage-finished beef roasts with a solution of salt and phosphate improved the palatability of forage-finished beef. While many of these methods may improve the flavor characteristics of forage-finished beef, current labeling regulations for grass- or forage-fed beef may severely limit these strategies to postmortem technologies.

**Beef Tenderness**

Similar to the issue of beef flavor, tenderness of forage-finished beef is extremely variable. One of the traditionally used reasons for not producing forage-finished beef is that it produces a less tender product as measured by Warner-Bratzler shear values and sensory panels (Smith et al., 1977; Cranwell et al., 1996; Crouse and Seideman, 1984). However, other research indicates that no tenderness differences between forage-finished and grain-finished beef exist (Dinus and Cross, 1978; Sapp et al., 1999). In fact, Kerth et al. (2007) reported tenderness differences between forage- and grain-finished beef in longissimus muscle from strip loins, but found no differences in tenderness between finishing regimens in the longissimus muscle of the ribeye roll from the same steers.

Muscle collagen type and amount have long been known to play a significant role in meat tenderness, and in particular, may account for some of the differences in tenderness of forage-finished beef. Cox et al. (2006) reported no differences in either total or heat-labile collagen of longissimus muscle from forage- or grain-finished beef, but did report that myofibrillar fragmentation index (a crude measure of myofibrillar protein degradation during postmortem aging) did not increase during postmortem aging of forage-fed beef.

Smith et al. (1979) explored several methods of tenderizing forage-fed beef, including electrical stimulation of carcasses, delayed chilling of carcasses, pelvic suspension of sides, cooler aging, and blade tenderization of wholesale loins and top rounds. It was found that maximum tenderization of the longissimus muscle was achieved by either electrical stimulation or delayed chilling of sides followed by either cooler aging or blade tenderization of shortloins. None of the initial tenderization treatments increased the tenderness of the semimembranosus muscle, however combined treatments of initial methods followed by blade tenderization increased tenderness and decreased shear force of the top round steaks.

Bidner et al. (1981) also used electrical stimulation, blade tenderization and vacuum aging to tenderize forage-finished beef. It was found that the electrical stimulation had a significant effect on Warner-Bratzler shear force while having no effect on palatability. Additionally, blade tenderization and vacuum aging improved shear values and taste panel tenderness as well as connective tissue amount. It was also found in this study that there was a benefit to tenderization by combining treatments. The steaks that had been both electrically stimulated and either blade tenderized or va-
and vacuum aged were more tender than those steaks that had received only one of the treatments.

**Lean And Fat Color**

Similar to the issues of beef flavor and tenderness, conflicting data exists on the color of lean in forage-finished beef as compared to grain-finished beef. Research indicates that the lean color of forage-finished beef is darker than grain-finished beef (Bidner et al., 1981; Abdullah et al., 1979; Crouse and Seideman, 1984). Research has also indicated that there is no significant difference in the lean color of forage-finished and grain-finished beef (O'Sullivan et al., 2003; and Sapp et al., 1999).

The appearance of beef fat is primarily affected by the deposition of carotenoids and hemoglobin derivatives, the reflectance, transmittance, and fluorescence of lipids, and the reflectance and fluorescence of non-lipid components (Irie, 2001). The research concerning the fat color of forage-finished beef generally agrees that forage-finished beef fat has a more yellow or creamy color than the whiter concentrate-finished beef fat color (Strachan et al., 1993; Bennett et al., 1995; Cranwell et al., 1996). However, Kerth et al. (2007) reported that trimming subcutaneous fat of forage-finished beef to 0.3 cm (similar to current commercial fabrication practices) resulted in significantly higher L* (whiteness) and lower b* (yellowness) values in forage-finished beef. In fact, fat b* values of forage-finished beef after trimming were similar to b* values of grain-finished beef prior to trimming.

**Lipid Characteristics**

The underlying factor that plays a role in beef flavor, color and even sensory tenderness is the composition of the lipid portion of beef. In some respects, the lipids of forage-finished and grain-finished beef are similar. Montgomery and Bidner (1981) analyzed the phospholipids in forage-finished and grain-finished beef and found very little difference between polar lipids in both types of beef. Additionally, the quantities of spingomyelin, phosphatidylethanolamine, and phosphatidylcholine were very similar between treatments. Significant differences do exist, however, between these two types of beef fat that are notable. Research typically agrees that with the increase in forage in the diet of a ruminant animal, there is an increase in the percentage of polyunsaturated fatty acids in the fat of the animal (Yang et al., 2002; Wood et al., 2003; and Mitchell et al., 1991). The omega-3 fatty acids are of particular interest to many forage-finished beef producers and they are in higher abundance in forage-finished beef.

The higher percentage of polyunsaturated fatty acids found in forage-finished beef may provide a significant number of health benefits to humans, however, this type of fat also causes forage-finished beef to be more susceptible to oxidation. This, in turn, significantly affects the color and fat oxidative stability of the beef in a retail setting. Thus some researchers have investigated the naturally occurring and supplemented anti-oxidants found in forage-finished beef. Of particular interest to many researchers is that forage-finished beef contains a much higher percentage of alpha-tocopherol in comparison to concentrate-finished beef (Yang et al., 2002; Wood et al., 2003). While having a higher percentage of polyunsaturated fatty acids in their fats, forage-finished animals also consume a higher percentage of naturally occurring anti-oxidants. While supplementation of alpha-tocopherol to concentrate-finished animals has increased plasma concentrations of the anti-oxidant, and thus reducing oxidation of the beef, there appears to be no additional anti-oxidant benefit of supplementing alpha-tocopherol to forage-finished animals (Yang et al., 2002).

Reverte et al. (2003) observed the effects of adding propyl gallate and a beefy flavoring agent to restructured beef steaks from forage-finished animals. The flavoring agent masked the flavor of the forage-finished beef and made it more acceptable to consumers. More interestingly, the propyl gallate retarded oxidation and rancidity development during extended frozen storage. Additionally, color scores, cooking yield and binding strength changed very little with the presence of propyl gallate. Thus, the study concluded that the combination of flavoring agents and antioxidants provides an effective means to enhance the palatability and storage stability of beef from forage-finished cattle.

**Consumer Acceptance**

While many advances in production and processing technologies have offset many of the negative concerns of forage-finished beef, the bottom line is that a market must exist for this type of beef in order to be successful. Much of our research has centered on determining the consumer acceptance of forage-finished beef and determining the factors that are of importance to the consumer. It is here that a majority of confusion exists regarding the production, processing, and eventually marketing of forage-finished beef. While a relatively small sampling, Kerth et al. (2007) found that traditional “steak quality” was still by far the most important factor for consumers when selecting steaks. This far outweighed (>75% of respondents selected steak quality) other factors like locally-grown, forage-finished, CLA, and other attributes commonly associated with forage-finished beef.

The seasonality of producing forage-finished beef is a major concern and can only partially be offset by the ability to produce high quality forages throughout the year in the southeastern U.S. Additionally, with no major commercial packing plants in the Southeast, the logistics of producing forage-finished beef are fairly daunting. The economics of production are just now justifying the pursuit of developing a processing strategy for this segment of the beef industry, but only if a significant portion of the market is willing to purchase forage-finished beef.

Umberger et al. (2002) reported that about 20% of consumers surveyed preferred Argentine forage-finished beef to traditional American grain-finished beef. Additionally, Cox
et al. (2006) and Kerth et al. (2007) reported that as many as 34 and 56% (respectively) of consumers surveyed in the southeastern U.S. preferred the taste of beef that was finished in whole or in part on forage. So while a large majority of consumers still prefer the taste of traditional grain-finished beef, research indicating that as many as 1/3 to 1/2 of the consumers prefer forage-finished beef gives a strong signal that, indeed forage-finished beef has a future in the U.S.

References

Abdullah M; Bidner TD; Carpenter Jr. JC; Schupp AR; Pontif JE; Koonce KL. 1979. Forage-fed versus short-fed beef as influenced by breed type. Livestock Producers’ Day Report. 19: 146-151.

Bennett LL; Hammond AC; Williams MJ; Kunkle WE; Johnson DD; Preston RL; Miller ME. 1995. Performance, carcass yield, and carcass quality characteristics of steers finished on rye- and oat-based tropical grass pastures, or concentrate. Journal of Animal Science. 73: 1881-1887.


Chen ME; Davidson PM; Riemann MJ. 1984. Microbiological and sensory characteristics of patty formulations containing beef from grass-fed steers and fat beef or pork trim. Journal of Food Protection. 47: 200-205.

Cox RB; Kerth CR; Gentry JG; Prevatt JW; Braden KW; Jones WR. 2006. Determining acceptance of domestic forage- or grain-finished beef by consumers from three southeastern USA states. J. Food Sci. 71:S542-S546.


French P; O’Riordan EG; Monahan FJ; Caffrey PJ; Vidal M; Mooney MT; Troy DJ; Moloney AP. 2000. Meat quality of steers finished on autumn grass, grass silage or concentrate-based diets. Meat Science. 56: 173-180.


Mandell IB; Buchanan-Smith JG; Campbell CP. 1998. Effects of forage vs. grain feeding on carcass characteristics, fatty acid composition, and beef quality in Limousin-cross steers when time on feed is controlled. Journal of Animal Science. 76: 2619-2630.

McMillin KW; Bidner TD; Hill GM; Bagley CP; Knox JW; Coombs DF; Loyacano AF; Oliver WM. 1982. Carcass traits of slaughter beef finished on forage diets. Livestock Producers’ Day Report. 23: 125-128.

McMillin KW; Bidner TD; Montgomery RE; Canal MJ; Carothers JT; Wu YC; Felche; SE. 1984. Mean carcass traits of slaughter cattle from the year round forage beef production project. Livestock Producers’ Day Report. 25: 26-30.


Melton SL; Black JM; Davis GW; Backus WR. 1982. Flavor and selected chemical components for steers backgrounded on pasture and fed corn up to 140 days. Journal of Food Science. 47: 699-704.


Sapp PH; Williams SE; McCann MA. 1999. Sensory attributes and retail display characteristics of pasture- and/or grain-fed beef aged 7, 14 or 21 days. Journal of food quality. 22: 257-274.

Schnell TD; Belk KE; Tatum JD; Miller KK; Smith GC. 1997. Performance, carcass, and palatability traits for culled cows fed high-energy concentrate diets for 0, 14, 28, 42, or 56 days. Journal of Animal Science. 75: 1195-1202.


Wood JD; Richardson RI; Nut GR; Fisher AV; Campo MM; Kasapidou E; Sheard PR; Enser M. 2003. Effects of fatty acids on meat quality: a review. Meat Science. 63.

Xiong YL; Moody WG; Blanchard SP; Liu G; Burris WR. 1996. Postmortem proteolytic and organoleptic changes in hot-boned muscle from grass-and grain-fed and zeranol-implanted cattle. Food Research International. 29: 27-34.
Yang A; Lanari MC; Brewster M; Tune RK. 2002. Lipid stability and meat colour of beef from pasture- and grain-fed cattle with or without vitamin E supplement. Meat Science. 60: 41-50.