Sire Selection and Meat Quality

Michael E. Dikeman, PhD
Department of Animal Sciences and Industry, Kansas State University, Manhattan, Kansas 66506

Abstract

Today's beef industry primarily is "consumer driven." This means that consumers have certain expectations for the quality and price of beef, and that demand will decrease if those expectations are not met. Beef processors, purveyors, and retailers also have certain expectations for the cattle, carcasses, and boxed subprimal cuts they purchase for processing. Cattle have to be fed to a certain level of fatness in order to have a high dressing percentage and to express their genetic potential for marbling. However, the relationship between fatness and marbling (quality grade) is not very high. In the U.S. beef industry, marbling receives considerable emphasis as a determinant of beef quality and it has a greater effect on value differences among carcasses and cuts than does meat yield percentage. There is a genetic antagonism between marbling and meat yield percentage that must be managed in cattle production, especially for the large "retail" quality target. Although over simplified, there are three primary beef quality targets for which cattlemen should aim. In producing beef for the "white tablecloth" quality target, breeds that have high marbling potential, such as Angus and Red Angus, are best suited. In this target, meat yield percentage will be compromised. In producing beef for the "lite/lean" quality target, high percentage Continental breeds that yield a high percentage of meat, such as Limousin, Charolais, Simmental or Gelbvieh, are best suited. In this target, tenderness and other palatability traits will be compromised to some extent. In producing beef for the large "retail" target, crosses of Continental breeds, such as Charolais and Simmental, with British breeds, such as Angus and Red Angus, work best to manage the genetic antagonism between marbling and meat yield percentage. This system "optimizes" meat quality and meat yield percentage and is a very efficient production system. Because marbling is not an accurate predictor of tenderness, selecting directly for tenderness would be more effective. Expected Progeny Differences (EPDs) of Warner-Bratzler shear force, an instrumental measure of cooked meat tenderness, have been published by several U.S. beef cattle breed associations for the most widely used sires in those breeds. These EPDs resulted from a national project coordinated by the National Cattlemen's Beef Association in the U.S. to improve carcass traits and meat palatability genetically. Preliminary results from this project also suggest that, in the future, DNA "marker" analysis could be used as a selection tool for carcass and meat traits. Cattlemen should select sires from breeds that excel in the carcass traits of interest and that have relatively accurate EPDs for those traits.

Introduction

Beef producers have been 'guilty' in the past of "trying to sell what they have produced" rather than "produce what they can sell". Today's beef industry is 'consumer driven', which means that consumers have certain demands and expectations of beef and that they will cease to purchase beef if it does not meet their demands. Consequently, the beef industry must keep focus on producing cattle that yield carcasses that meet demands of beef processors, and beef that meets demands of purveyors, retailers, and, most importantly, consumers.

Discussion

Beef Processor, Retailer, Purveyor, and Consumer Demands. U.S. **beef processors** demand cattle that: 1) dress at least 63%; 2) produce carcasses that are all within the range of 550 to 950 lb.; 3) grade 60 to 70% USDA Choice and Prime, 25 to 35% USDA Select and less than 2% USDA Standard; and 4) grade at least 97% USDA yield grades 1, 2, and 3. In addition, they want less than 2% of the carcasses to be dark-cutters, or have significant bruises or abscesses. This would allow them to fabricate over 90% of carcasses into boxed beef. Canadian **beef processors** probably have similar demands for dressing percent and carcass weight and for 60 to 70% of cattle to grade AA, AAA or Prime, and a high percentage of yield classes 1 and 2. These are realistic demands by U.S. and Canadian beef processors that the cattle industry should strive to attain.

Retailers and **purveyors** realistically want the same or better quality grade mix, but want primal and

subprimal cuts from a narrower carcass weight range. Obviously, some retailers and purveyors want beef of higher quality than others. They also want beef from carcasses that have been optimally stimulated with electricity and that have been aged longer than at present before purchase. They also want boxed beef that has been closely trimmed instead of the 3/4 inch trim that, in the past, has been the standard for the U.S. industry, and they are willing to pay the price difference for the closely trimmed product. **Consumers** want beef that is: 1) safe and wholesome; 2) reasonably priced; 3) closely trimmed and lean; and 4) **consistently** acceptable in tenderness, flavor and juiciness.[2] At the same time, they need to be educated on how to cook meat, and the fact that method of cookery and degree of doneness can have dramatic effects on beef's tenderness, flavor and juiciness. However, educating consumers is an extremely challenging and slow process.

Carcass Quality and Composition. For steers and heifers slaughtered by 28-30 months of age (that are not dark cutters), USDA quality grade is based almost entirely on degree of marbling. The current USDA quality grade chart is shown as Figure 1[11]. The Canadian beef grading system puts a little less emphasis on marbling. Cattle must be fed a high-grain diet for a minimum of 90 to 100 days and reach a certain level of fatness before they deposit enough intramuscular fat (marbling) to grade low Choice or higher. Marbling is the least essential for survival and, therefore, is deposited late in the finishing phase. The Agriculture Canada classification corresponding to low Choice is AAA. According to the 2000 National Beef Quality Audit in the U.S.[10], data on several thousand carcasses show that the average fat thickness was 0.49 inches (1.23 cm), the average yield grade was 3.0, and the average marbling score was low Small. Furthermore, 11.7% of the carcasses were yield grades 4 and 5 (the fatter half of Canadian yield 3 class). Carcasses with a USDA 3.0 yield grade typically will have about 17 to 20% trimmable fat. For a 700 lb carcass, that is about 130 lb of trimmed fat, and that doesn't include visceral fat that is removed when cattle are slaughtered. Clearly, cattle produce a significant amount of excess fat at an average of 0.49 inches of 12th rib fat thickness. This fat must be reduced if the beef industry is to remain competitive with other meat sources.

Cattle are fed to 0.50-0.60 inches of fatness so they will have a high dressing percent and so they will have a high probability (60 to 70%) of grading low Choice (Canadian AAA) or higher. Interestingly, only 51.4% of the carcasses sampled in the 2000 National Beef Quality Audit graded low-Choice or higher. Although this low percentage is partially attributable to some 'dark-cutting' and B-maturity carcasses being discounted in quality grade, some cattle do not have the genetic potential to deposit adequate marbling to grade Choice or AAA. Consequently, the relationship between fatness and quality grade is not very high in the wide diversity of cattle types that exists in the U.S.

Genetic Antagonism. At this point, it should be emphasized that there is a **genetic antagonism** between marbling (quality grade) and percentage yield of closely trimmed meat. This means that if the only carcass trait selected in cattle is marbling, percentage yield of closely trimmed meat will decrease. Or, if the only two traits selected in cattle are decreased fat and increased muscling, marbling will then decrease. Figure 2 shows the relationship between marbling score and percentage yield of meat for breeds of cattle in Cycles I, II and III of the Cattle Germ Plasm Evaluation (GPE)

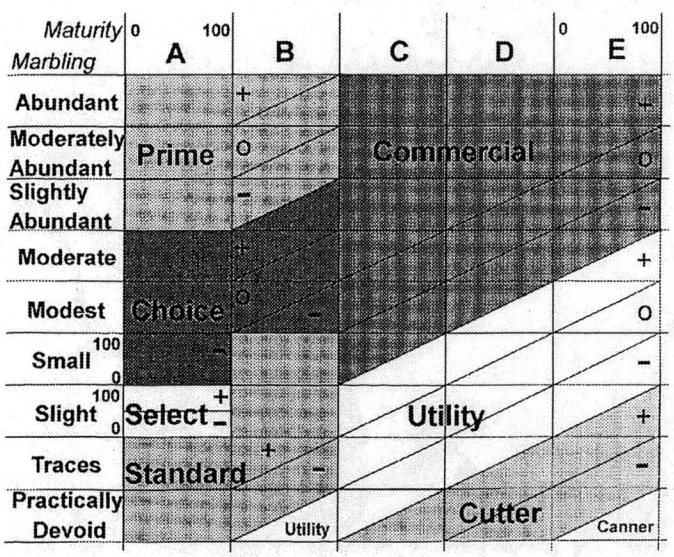

Figure 1. USDA beef quality grading chart.

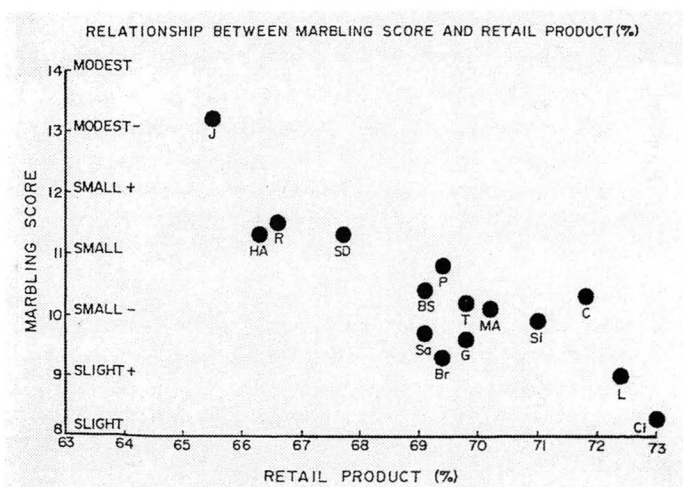

Figure 2. Breed group means for retail product percentage versus marbling score at 458 days of age. From Koch *et al.*[7,8,9]

project conducted cooperatively between the U.S. Meat Animal Research Center (MARC), Clay Center, Nebraska and Kansas State University.[7,8,9] Dr. Larry Cundiff at MARC directs the GPE program and I have cooperated on the project. This is the most extensive project in the world to characterize different biological types and(or) breeds of cattle for production, carcass and meat traits. Because of the genetic antagonism between marbling and meat yield percentage, progress in selecting for both at the same time will be relatively slow. However, just as purebred bulls can be identified by the use of EPDs that have below average birth weights and above average yearling weights, it is possible to identify sires that have genetic potential for above average marbling and muscling and below average fatness. Yet, only a few breed associations have adequate data to generate EPDs for carcass traits on a significant number of bulls registered. Because of the time lag between when a sire is mated to females and when his progeny are slaughtered (about 2-1/2 years), and because purebred breeders generally do not feed out steers and heifers, and because carcass data have not always been easy to obtain, insufficient data are available in some breeds to make progress towards selecting for increased marbling and reduced fatness (increased meat yield). Consequently, an alternative approach must be used in the short term to manage the genetic antagonism that exists between marbling (quality grade) and percentage of meat yield.

Beef Quality Targets. There appears to be three basic quality targets for fed beef to meet the real or perceived demands of consumers.[2] The highest quality target is beef for the **"white tablecloth"** eating experience. This segment of consumers expects the ultimate in tenderness, flavor and juiciness. They are not very concerned about price, cholesterol, saturated fat or nutritional value in those eating experiences. However, they likely will not eat trimmable or separable fat ("plate waste").

The other extreme from the "white tablecloth" quality target is the **"lite" or "lean"** target. Consumers who are diet-health conscious are most concerned about leanness and are willing to give up some taste and tenderness to get leanness. They are not necessarily price conscious, but nutritional value and very low fat are primary concerns.

Probably the largest consumer segment is the **"retail"** target. Consumers want this beef to have sufficient marbling for desirable taste and tenderness, but not have excess fat, either in the form of outside fat or seam fat. Consumers in this primary target group want the "optimum" in price, palatability, nutritional value and leanness. Managing the genetic antagonism between marbling and percentage of meat yield is most difficult for this quality target.

Cattle intended for the white tablecloth target should include a minimum of 75% Angus, Red Angus, or Shorthorn breeding and little or no *Bos indicus* breeding. Breed means for percentage of carcasses grading USDA Choice for these breeds are shown in Tables 1, 2, and 3.[1,7,8,9,12] These cattle probably should be grown and developed on forage for a few months before finishing for 110 to 160 days on a high concentrate diet. This should allow for some increase in carcass weight while maintaining acceptable fatness. It should be emphasized, however, that probably only 20 to 50% of these carcasses will meet the minimum quality criteria of average Choice ("premium" Choice) and that a percentage of the carcasses likely will be USDA yield grade 4's. In the Canadian system, a high percentage should be 'specification' AAA and a high percentage will be yield classes 2 and 3. Heifers of this breeding must be marketed on a very timely basis to avoid an excess of USDA yield grade 4's or Canadian 3's. Producing cattle for this target contradicts the goal of reducing excess fat in cattle and carcasses established by NCBA's Task Force on Value-Based Marketing. The price discounts for USDA yield grade 4's or Canadian 3's will have to be weighed against the premiums received for carcasses that meet the average Choice quality minimum for this target. Currently, the yield grade 4 discounts are greater than the quality premiums. Examples of programs utilizing this quality of beef in the U.S. would be Sterling Silver, Chefs' Exclu-

"Specs" for Cattle to fit the "WHITE TABLECLOTH" Target

Live weight range:	1050 to 1350 lb
Dressing % minimum:	63%
Frame size range:	USDA Medium-to-Large (4+ to 6)
Muscle score range:	USDA 2 to 3
Ribeye area range:	11.0 to 13.0 sq in; Canadian 2 and 3 muscle scores
Fat thickness range:	0.50 to 0.75 in; 1.3 to 1.9 cm
Yield grade mix:	USDA 2's and 3's with a max. of 10% 4's; Canadian yield class 2 and 3
Age range:	16 to 28 months
Quality grade **minimum**:	USDA Average Choice (≥Modest marbling); Specification Canadian AAA and Prime

Table 1. Breed means for percent choice carcasses, percent retail product, Warner-Bratzler Shear Force, and taste-panel tenderness[a].

Breed	Percent Choice	Retail product, %	Warner-Bratzler shear, lb.	Taste-panel tenderness[b]
Sahiwal-X	44%	69.1%	9.1	5.8
Brahman-X	40%	69.4%	8.4	6.5
Tarentaise-X	60%	69.8%	8.1	6.7
Chianina-X	24%	73.0%	7.9	6.9
Gelbvieh-X	43%	69.8%	7.8	6.9
Simmental-X	60%	71.0%	7.8	6.8
Limousin-X	37%	72.4%	7.7	6.9
Brown Swiss-X	61%	69.1%	7.7	7.2
Maine Anjou-X	54%	70.2%	7.5	7.1
Pinzgauer-X	60%	69.4%	7.4	7.1
Red Poll-X	68%	66.6%	7.4	7.3
Hereford-Angus-X	76%	66.3%	7.3	7.3
Charolais-X	63%	71.8%	7.2	7.3
South Devon-X	76%	67.7%	6.8	7.4
Jersey-X	85%	65.5%	6.8	7.4

[a]From Cycles I, II and III of the Germ Plasm Evaluation project, U.S. Meat animal Research Center, Clay Center, Nebraska and Kansas State University, Manhattan. From Koch et al.[7,8,9]
[b]Score of 5 = acceptable, 6 = slightly desirable, 7 = moderately desirable, 8 = very desirable and 9 = extremely desirable.

Table 2. Breed means for percent choice carcasses, percent retail product, and Warner-Bratzler shear value[a].

Breed	Percent Choice	Retail product, %	Warner-Bratzler shear value, lb
Pinzgauer-X	63.5%	65.1%	11.2
Original HA-X	77.5%	62.1%	11.8
Piedmontese-X	43.5%	69.8%	11.9
Current HA-X	71.3%	62.5%	12.3
Gelbvieh-X	46.1%	66.4%	12.5
Galloway-X	59.9%	65.2%	12.8
Shorthorn-X	76.2%	62.5%	12.9
Charolais-X	51.8%	66.0%	13.0
Longhorn-X	58.1%	65.1%	13.4
Salers-X	45.3%	65.7%	14.0
Nellore-X	45.8%	64.7%	15.8

[a]Data are from Cycle IV of the GPE project, U.S. Meat Animal Research Center, Clay Center, Nebraska. Kansas State University cooperated. Data are from ribeye steaks from 994 steer carcasses. From Cundiff et al.[1]
[b]Retail product was trimmed free of surface fat, which was closer than for Cycles I, II, and III in Table 1.
[c]Cooking and shearing procedures were different than for Cycles I, II, and III in Table 1.

Table 3. Breed means for marbling score, percentage of retail product, and Warner-Bratzler shear value[a].

Breed	Marbling score[b]	% Retail product[c]	Shear value, lb[d]
Red Angus-X	Small[89]	57.7	9.0
Angus-X	Small[77]	58.9	8.4
Hereford-X	Small[38]	59.5	8.8
Charolais-X	Small[17]	62.2	9.5
Simmental-X	Small[36]	62.2	8.8
Gelbvieh-X	Small[14]	62.4	9.7
Limousin-X	Small[07]	62.9	9.0

[a]Data are from Cycle VI of the GPE project, U.S. Meat Animal Research Center, Clay Center, Nebraska. From Wheeler et al.[13]
[b]Percentage within the Small degree of marbling in the USDA Quality Grade standards.
[c]Retail product percentage was measured slightly differently than in Cycle IV and V in Tables 2 and 4.
[d]Cooking and shearing procedures were different than for Cycles I, II, and III in Table 1.

sive and Certified Angus Beef. The Certified Angus Beef program is the largest branded beef program in the U.S. and continues to grow. As shown in Table 1, South Devon cattle can attain Choice marbling equivalent to Hereford-Angus crosses and yield a higher meat yield percentage. However, the numbers of South Devon as well as Shorthorn cattle are relatively small compared to the Angus breeds.

In producing cattle to meet the white tablecloth quality target, some carcasses will grade USDA or Canadian Prime. Although only 2-4% of carcasses qualify for Prime, they command a premium price to meet the "elite white tablecloth" target.

It seems logical that if cow-calf producers produce Angus, Red Angus, and (or) Shorthorn calves or their crosses to fit the white tablecloth quality target, they should seriously consider retaining ownership of those calves through the backgrounding and feedlot phases. Retained ownership provides an opportunity to benefit more fully from cattle that have been produced to meet a specific quality target. For cattlemen who are targeting their steer production for the high quality white tablecloth target, selling replacement females could be an excellent alternative market to feeding out the heifers. More selection emphasis could be placed on maternal traits and marbling than when trying to select for these traits plus muscling and reduced fat.

Cattle best fitted for the "lite/lean" quality target are those that have 75% or more "Continental" breeding, such as Limousin, Charolais, Simmental, Maine Anjou, Salers or Gelbvieh. These cattle should be preconditioned and ready to be started on a high energy finishing diet by 9 to 10 months of age and slaughtered at 13 to 16 months of age. These cattle will have very rapid, efficient gains and result in a high percentage of carcasses grading Select or Canadian AA, with 30 to 50% grading low Choice or AAA and 5 to 15% grading Standard or A (Tables 1 and 2).[1,7,8,9] They should be nearly 100% USDA or Canadian yield grade 1's and 2's and produce retail cuts that are very lean and have high nutritional value. The genetic antagonism between marbling and percentage of meat yield is not as important for this quality target because of the lower marbling requirement. However, tenderness, flavor and juiciness of steaks from the Standard carcasses will create some problems. The low Choice or AAA carcasses resulting from this system will readily fit the "retail" quality target. Backgrounding or growing these cattle and(or) feeding them to primarily meet the "retail" quality target will not work very well because they will not deposit enough finish at acceptable carcass weights and(or) do not have the genetic potential for marbling to attain a high percentage of Choice or AAA carcasses.

In the future, it is possible that breeds with muscular hypertrophy (sometimes called "double-muscled"), such as Piedmontese or Belgian White Blues, might increase in numbers to adequately meet this target. Beef from these two breeds is extremely lean, yet tender (Table 4).[13] However, these breeds are still relatively small in numbers.

Cattle best fitted for the large "retail" quality target are Continental-breed sired calves out of British breed dams noted for high marbling. These cattle will perform very well in the feedlot and will produce 60 to 70% Choice or AAA carcasses that are mostly USDA and Canadian yield grade 2's and mostly weigh in the ideal range of 650 to 850 lb (Tables 1 and 2). Those that do not grade Choice or AAA but are in the upper half of Select or AA still work very well for the retail trade because they will have been "fed to be Choice" or AAA and their beef will be tender, flavorful and juicy. The genetic antagonism for this large quality target is the most difficult to manage because price, quality, nutritional value and leanness all must be optimized to meet processor, retailer, purveyor and consumer demands.

Sire breeds most ideal for the retail target are Charolais and Simmental mated to Angus or Red Angus; Angus or Red Angus X Hereford crossbred dams; Shorthorn or Shorthorn X Hereford, Angus or Red Angus crossbred dams. Both steers and heifers of these crosses produce excellent carcasses. This crossbreeding system is an excellent way to manage the genetic antagonism that exists between marbling and percentage of meat yield. The genetics for high marbling are

"Specs" for Cattle to fit the "LITE" or "LEAN" Target

Live weight range:	1200 to 1400 lb
Dressing % minimum:	64%
Frame size range:	USDA Large (6 to 7)
Muscle score range:	USDA 1 and 2
Ribeye area range:	13.0 to 15.0 sq in; Canadian 3 and 4 muscle score
Fat thickness range:	0.20 to 0.30 in; 0.5 to 0.75 mm
Yield grade mix:	100% USDA 1's and 2's; Canadian 1's and 2's
Age range:	13 to 16 months
Quality grade **minimum**:	USDA Standard$^+$ and Select; Canadian A and AA

"Specs" for Cattle to fit the "RETAIL" Target

Live weight range:	1100 to 1350 lb
Dressing % minimum:	63%
Frame size range:	USDA Medium-to-Large (5+ to 6)
Muscle score range:	USDA 2 and 3
Ribeye area range:	12.0 to 14.0 sq in; primarily Canadian 2 muscle score
Fat thickness range:	0.35 to 0.60 in; 0.9 to 1.5 cm
Yield grade mix:	Mostly USDA 2's and 3's; and Canadian 2's
Age range:	14 to 20 months
Quality grade **minimum**:	'Specification' Select and(or) Choice; Canadian AA and AAA

Table 4. Breed means for percentage grading choice, percentage of retail product and Warner-Bratzler shear value[a].

Breed	Percent Choice	% Retail product[b]	Shear value, lb
Hereford-X	70.8	61.5	13.0
Angus-X	90.6	63.4	12.6
Brahman-X	23.4	64.6	17.9
Boran-X	54.7	62.3	16.1
Tuli-X	80.5	61.9	13.0
Piedmontese-X	35.5	71.1	12.8
Belgian Blue-X	21.3	69.2	12.8

[a]Preliminary results from Cycle V of the GPE research at the U.S. Meat Animal Research Center, Clay Center, Nebraska.
[b]Percentage of retail product trimmed free of surface fat and lean trim containing 20% fat.
[c]Cooking and shearing procedures were different than for Cycles I, II, and III in Table 1.

contributed by the Angus, Red Angus or Shorthorn breeds[12], and the genetics for rapid growth, increased muscling and decreased fatness are contributed by the Continental breeds. Crossing Gelbvieh and Limousin sires with Angus, Red Angus or Shorthorn dams also works well for the retail target. However, their meat quality is a little lower than for Charolais and Simmental (Tables 1 and 3), and mating them to Hereford crossbred dams can result in a lower percentage of Choice or AAA carcasses. Maine Anjou, Salers, and South Devon sires also cross reasonably well with British dams for this target (Tables 1 and 2).

In a Continental sire X British dam crossbreeding system, maintenance feed requirements are kept to a minimum with the more moderate-sized, easier fleshing British dams. This is an excellent production system when it is utilized as a 'terminal' sire system in which all female progeny are slaughtered along with the steers. A 'terminal' sire system dictates that cattlemen purchase replacement females; it is more difficult to manage when replacement females are retained. Heifers retained should be mated to breeds known for calving ease, which results in progeny that are only 1/4 Continental X 3/4 British. After the retained heifers have had two calves and are mated to Continental sires, their progeny will be 3/4 Continental X 1/4 British. This results in some variability in carcass traits, unless the progeny are fed and managed differently, which can be done. Although this crossbreeding system is more difficult to manage than simple rotational crossing, crisscrossing of breeds, or a straightbred system, it still is the most optimum system for managing the trade-offs that exist in the genetic antagonism between beef quality and percentage of meat yield. Furthermore, between-breed genetic variations are more easily exploited than genetic variations within breeds because between-breed genetic variations are more highly heritable.

An alternative to the terminal crossbreeding system described above is to use or develop "composite" breeds or to rotate F_1 crossbred bulls. Composites are developed from crossing specific breeds to capitalize on complementarity of different traits. Then, the composite is *inter se* mated to result in a "composite breed". Brangus, Santa Gertrudis, etc., are examples of composite breeds. The genetic variation in rotating F_1 males or similar-type composites is less than the genetic variation in a two breed rotation. Dr. Keith Gregory at the U.S. Meat Animal Research Center, Clay Center, Nebraska has developed three composite breeds and evaluated their performance. One of these is the "MARC II" composite that consists of 1/4 Angus, 1/4 Hereford, 1/4 Gelbvieh and 1/4 Simmental.[6] The MARC II combines desirable growth, efficiency, milk production, meat quality and percentage of meat yield in one composite. Another alternative production system would be to mate F_1 females to F_1 males of the same breeding. An example would be Gelbvieh X Red Angus F_1 females mated to Gelbvieh X Red Angus F_1 sires.

The American Hereford Association in the U.S. has established a "Certified Hereford Beef" branded program that is quite successful. Cattle have to be Hereford sired

and grade Select (AA) or Choice (AAA). Even though Herefords have below average marbling for their fatness, their beef is very tender and flavorful. Some retailers and popular restaurants feature "Certified Hereford Beef".

The proportion of *Bos indicus* breeding in cattle for the retail target should not exceed 3/8, and 3/16 is more desirable from a carcass/meat standpoint. More than 3/8 *Bos indicus* breeding results in decreased marbling and ribeye size and a less desirable yield grade. In addition, rib and loin steaks from cattle with 1/2 or more *Bos indicus* breeding generally are less tender than those from cattle with less than 3/8 *Bos indicus* breeding.[8,9,13] Thus, there is a genetic antagonism between increasing *Bos indicus* breeding, and marbling and tenderness. Composite *Bos indicus* breeds such as Brangus and Santa Gertrudis can be used successfully in regions where heat tolerance is important. These breeds were developed to maintain heat tolerance and to add marbling and tenderness to the Brahman breed.

Carcass Value Differences. Meat processors clearly are willing to pay for quality grade differences in cattle. USDA Choice grade carcasses generally are priced from $3 to $12 per 100 lb higher than USDA Select carcasses. Although prices for Standard grade carcasses are difficult to obtain, they may be discounted $10 to $20/100 lb below Choice prices. Beef from Standard (A) grade carcasses usually is less tender and less juicy than beef from Select (AA) or low Choice (AAA) carcasses, which results in consumer dissatisfaction and reduced consumer demand for beef.

Beef processors definitely penalize USDA yield grade 4 carcasses! Price discounts can range from $10 to $20 per 100 lb of carcass. That means a 750 lb yield grade 4 carcass will be worth $75 to $150 less than a 750 lb yield grade 3 carcass of the same quality grade. Feeding on that excess fat is costly too! Even after purveyors or retailers trim off most of the fat from cuts out of a yield grade 4 carcass (which requires extra labor), consumers still discriminate against those cuts because of excessive seam fat. So, yield grade 4 cattle and carcasses are very costly to the industry, and generally are not fabricated into boxed beef, but sold at a discount to some purveyors. Even carcasses in the upper half of USDA yield grade 3 are too fat as they can have up to 0.8 in (2.0 cm) of 12th rib fat thickness.

Beef processors also pay premiums for carcasses of USDA yield grades 1 and 2 relative to yield grade 3. These premiums range from $3 to $5 for yield grades 1 and 2 and $2 to $3 for yield grade 2's. When boneless retail cuts are trimmed to 1/4 inch or less of fat cover, yield grade 2 carcasses will yield about 4.0% more total meat than yield grade 3 carcasses. That equates to 28 lb more meat out of a 700 lb carcass.

Genetic Selection for Meat Quality. The U.S. beef industry currently places considerable emphasis on marbling as the primary indicator of beef quality. Although the heritability of marbling is high (≈38%), and there are distinct marbling differences among breeds, marbling is not an accurate predictor of tenderness. It also may not be a good predictor of juiciness because method of cooking and degree of doneness can have dramatic effects on juiciness as well as tenderness. Although consumers eat beef primarily for its great flavor, complaints about the palatability of beef usually are because it is not acceptable in tenderness. Except for the tenderloin, significant percentages of nearly all beef cuts are not acceptable in tenderness. Recent market surveys have shown that consumers are willing to pay more for beef of known tenderness.

Although consumers are the ultimate judges of whether or not beef is desirable or undesirable in tenderness, Warner-Bratzler shear force is a highly repeatable and economical method for measuring tenderness. Reviews of published literature on the genetic control of tenderness show that the heritability of Warner-Bratzler shear force is moderately high (29%), indicating that progress can be made through selection[3]. However, selecting for tenderness is more difficult and expensive than selecting for marbling, yet it would be more effective to select directly for tenderness than to select only for marbling. Expected progeny Differences (EPDs) have become "user friendly" tools for cattlemen to use in selecting for numerous traits; however, until recently, no cattle breed association had EPDs for Warner-Bratzler shear force or sensory evaluated palatability traits. Recently, the American Simmental Association published EPDs for Warner-Bratzler shear force as a result of an NCBA coordinated Carcass Merit Traits research project. This extensive project involves Kansas State, Cornell, Colorado State and Texas A&M universities; 15 beef cattle breed associations; and Celera AgGen[4]. The primary objectives of this project are to facilitate development of EPDs for carcass and meat palatability traits and to validate previously identified DNA markers for these traits. DNA markers have been identified at Texas A&M University for tenderness and other quality traits and, if validated in this project, could potentially be used in 'marker-assisted' selection. With EPDs and(or) DNA marker-assisted selection, the beef cattle industry then can make significant progress toward improving meat tenderness and other palatability traits through genetic selection.

To date, EPDs have been developed and published for 47 Simmental and 10 Simbrah sires for Warner-Bratzler shear force as a measure of tenderness, which is a first for the beef industry[5]. Several other breeds should be developing EPDs within the next year. For breeds in which sufficient progeny have been slaugh-

tered, significant variation appears to exist to allow for genetic progress.

Table 5 lists Simmental and Simbrah sires that had seven or more progeny evaluated, their sire and maternal grandsire, their EPDs, the EPD accuracy, and the number or progeny slaughtered. The most tender Simmental sire had an EPD of -.51 lb of shear force and the least tender sire had an EPD of +.48 lb of shear force. The most tender Simbrah sire had an EPD of -.73 lb and the least tender sire had an EPD of +.73 lb. The accuracies still are relatively low for some of the sires because of small progeny numbers. The differences in these EPD values are large enough to allow for genetic improvement in tenderness when used in selection, particularly in the Simbrah breed.

Several breeds in the Carcass Merit Traits project have provided enough progeny to date for complete DNA analyses on several sires. A minimum of 66 'markers' are to be screened for each sire (11 Quantitative Trait Loci, QTL).[4] There are several QTLs for shear force and sensory panel tenderness; three for marbling, and one for ribeye area that were identified at Texas A&M University. The markers are not genes, but are random segments of DNA found at specific locations. Validation will determine if the QTL discovered in the Texas A& M experiment using Angus and Brahman cross cattle segregate within the various breeds in this project and, if so, which ones are heterozygous from sire to progeny. In an example where a sire is heterozygous for a marker, such as Warner-Bratzler shear force, the progeny with markers that flank the QTL on one of the pair of chromosomes will be associated with having a lower or higher shear force value than those with the other markers. Therefore, DNA marker analysis could be used in selection if a sire is heterozygous for the QTL of interest.

Preliminary results show that some markers identifying QTLs have been validated in several sires of the breeds where DNA analysis is complete. This suggests that the markers can be used as a selection tool for at least some traits for sires of some breeds.

Summary

Percentage of meat yield will continue to be a very important trait in the beef industry. Marbling will also continue to be an important economic trait, but direct selection for tenderness and other palatability traits would be more beneficial. The recent progress in development of EPDs for carcass and meat traits, particularly tenderness, will allow for genetic improvement. DNA analysis for markers identifying quantitative trait loci (QTLs) potentially can be used as a selection tool for at least some breeds. Until selection by the use of EPDs and(or) 'marker-assisted' selection for tenderness and other palatability traits become common tools, the beef cattle industry will have to continue to manage the genetic antagonism between marbling and meat yield percentage. To accomplish this, cattlemen will need to utilize sire breeds that are known to excel in the carcass and meat traits of interest and to breed and manage cattle to meet a specific quality target. Because there can be as much variation in some traits within a breed as between breeds, cattlemen should only utilize those breeds that have EPDs for carcass traits, whether selecting for meat yield percentage, marbling, tenderness, or all three simultaneously. When EPDs and(or) DNA markers are more readily available, cattlemen should then utilize only those breeds that have that information available.

References

1. Cundiff LV, Szabo F, Gregory KE, Koch RM, Dikeman ME, Crouse JD: Breed comparisons in the germplasm evaluation program at MARC. *Proc Beef Improvement Fed*, Ashville, NC, 1993.
2. Dikeman ME: Selection of bulls for carcass merit. *Proc Beef Bull Management Conference*, College of Veterinary Medicine, Kansas State University, 1994.
3. Dikeman ME: Genetic effects on the quality of meat from cattle. *Proc 4th World Cong on Genet Appl to Livestock Prod* XV:521, 1990.
4. Dikeman ME, Pollak EJ, Green RD, Taylor J, Davis S, Holm T, Koontz S, Gill C, Moser D, Westcott EA: Carcass merit project: Development of EPDs and genetic marker validation. *Kansas Agr Expt Sta Rep of Prog No. 873*, 2001.
5. Dikeman ME, Pollak EJ, Stroda SL, Lipsey RJ, Westcott EA: Carcass merit traits: Development of EPDs for Warner-Bratzler shear force and DNA marker validation. *Kansas Agr Expt Sta Rep of Prog No. 873*, 2001.
6. Gregory KE, Cundiff LV, Koch RM, Dikeman ME, Koohmaraie M: Breed effects and retained heterosis for growth, carcass and meat traits in advanced generations of composite populations of beef cattle. *J Anim Sci* 72:833, 1994.
7. Koch RM, Dikeman ME, Allen DM, May M, Crouse JD, Campion DR: Characterization of different biological types of cattle. III. Carcass composition, quality and palatability. *J Anim Sci* 43:48, 1975.
8. Koch RM, Dikeman ME, Crouse JD: Characterization of biological types of cattle (Cycle III). III. Carcass composition, quality, and palatability. *J Anim Sci* 54:35, 1982.
9. Koch RM, Dikeman ME, Lipsey RJ, Allen DM,Crouse JD: Characterization of biological types of cattle - Cycle II. III. Carcass composition, quality and palatability. *J Anim Sci* 49:448, 1979
10. NCBA: *2000 National Beef Quality Audit*. National Cattlemen's Beef Association, Greenwood Village, CO, 2000.
11. USDA: Official United States standards for grades of carcass beef. *Agric Marketing Serv*, USDA, Washington, DC, 1997.
12. Wheeler TL, Shackelford SD, Cundiff LV, Koohmaraie M: Preliminary carcass, yield, and Warner-Bratzler shear force traits of topcross steer progeny of Hereford, Angus, Red Angus, Simmental, Gelbvieh, Limousin, and Charolais sires. *Proc Midwestern Sect Amer Soc Anim Sci* 79(Suppl. 1):34(Abstr.), 2001.
13. Wheeler, TL, Cundiff LV, Koch RM, Dikeman ME, Crouse JD: Characterization of different biological types of steers (Cycle IV): Wholesale, subprimal and retail product yields. *J Anim Sci* 75:2389-2403, 1997.

Table 5. Simmental and Simbrah sire names, their sire and maternal grandsire, Expected Progeny Difference, accuracy, and number of progeny evaluated.

Simmental sire name	Sire/Maternal grandsire	WBSF[1] EPD	Accuracy	No. of progeny
3C Pasque 8773	Mr Abondance/Siegfrieds Powerthe	0.03	0.33	22
3C Wally C240	Emmons Black Hercules/HPS Night Rider	0.35	0.26	13
ALR Mr Lincoln	Cherithbrook Mr Abe/DS Polltime	0.24	0.16	9
ASR Cactus Red Z002	Polled Stretch/Alpine Polled Proto	0.3	0.35	42
Black Irish Kansas	Irish Black Knight/Kansas Black Jim	-0.09	0.42	37
Black Mick	Black Knight U2/Irish Rover	-0.04	0.31	20
Bold Future	Bold Ruler/H&S Pete	0.28	0.33	20
Boz Red Jet	Red Brother/Landridge Jet Black	-0.01	0.2	9
Burns Bull X339U	Black Max/Buck	0.14	0.29	17
Charles Pride	Copper Black S72/Landridge Jet Black	0.2	0.39	28
Circle S Leachman 600U	Landridge Jet Black/Steelman	-0.41	0.46	50
DS Zinger 141B	Hercules 538P/3X	0.15	0.29	15
DS Pollfleck 809	ABR Sir Arnold G809/Urspring	-0.24	0.29	15
Emmons Black Hercules	Landridge Jet Black/Hercules 538P	-0.21	0.31	21
ER Americana 537B	Black Max/Hercules 538P	-0.11	0.26	13
ER Big Sky 545B	ER Black Mack 568Y/Siegfried	-0.2	0.36	26
ER Mackfrid 550B	ER Black Mack 568Y/Siegfried	-0.25	0.32	21
F Nichols Black Advantage	Nichols Dynamite 9X/Buck	-0.18	0.33	19
Five Oaks Black Stretch	Polled Stretch/Buck	-0.35	0.21	11
GW Tailor Made 515A	Meyers Black Equalizer/T N T Mr T	0.45	0.27	16
HF/GF1 Powerline 7F	MV Red Light 406/Black Max	-0.51	0.23	11
J&C Black Maxi Van	J & C Black Maximizer W5/Extra	-0.19	0.21	17
Klondike Arnie GNM 250Z	SRF Mr Bigfoot S138/Bold	0	0.33	21
KSR Dr Pepper D405	Red Pepper/Grand Desire	0.03	0.27	21
LSR Preferred Stock 370C	Circle S Leachman 600U/Irish Black Knight	-0.16	0.28	12
Meyers Blacktop 206Y	Buck/Eagle	-0.33	0.31	17
Meyers Red Top	Meyers Blacktop 206Y/Chocolate Chip K34	-0.21	0.26	11
Nichols Big Easy D56	Nichols Dynamite 9X/Leachman Blk Baron 235X	-0.16	0.16	9
Nichols Black Destiny D12	CircleS Leachman 600U/Buck	-0.08	0.44	59
Nichols Blockbuster D100	Nichols Dynamite 9X/Buck	-0.3	0.25	30
Nichols Prime Rib E160	Nichols Prime Rib C139/F Nichols Black Advantage	-0.05	0.3	51
NLC Good A Nuff 33G	NLC 64 Tomcat/Leachman Red Baldy 438W	0.02	0.27	25
PVF-BF26 Black Joker	Harts Black Casino B408/Hercules 538P	-0.13	0.16	7
SRS Franchise F601	LRS Preferred Stock 370C/Meyers Black Power	-0.13	0.19	8
SSS Craftsman 004F	DS Black Zinger 141B/Black Polled Dakota	0.48	0.19	8
SV Red Charlie	Charles Pride/TT Red Delight	0.12	0.22	8
TKBS Mr Pride F164	Charles Pride/Meyers Blacktop 206Y	0.13	0.21	8
WHF Desperado 212G	PLT Cutting Edge D209/LRS Preferred Stock 370C	0.11	0.15	7
Simbrah sire name				
HR Nile King	PRR King Aurthur/Mr Pete 535P	0.46	0.31	21
K Bar Southern Comfort	RBR Leggacy/Red Rajah	-0.32	0.26	14
LL&L Blaze of Mississip	Mississippi	0.44	0.24	12
LMC Accountant 5A/174	LMC Money 8412P/5P Baliia 659	0.73	0.28	17
LMC Energizer 5B/155	Sir Nick 24Y/Wards Bravo 1/09	0.05	0.13	8
Parthenon Matador B218	K Bar Southern Comfort/Counter Sign	-0.48	0.29	18
PRR Pacesetter 205C	ISB MrX108X/RBR Net Profit	-0.06	0.28	16
RX Banner's B200	RX Polled Banner Zo2/AFI Honcho Supreme	-0.47	0.25	13
RX Colorado C332	HS Nail Z490 Abundance/RX Cognac 202	-0.73	0.26	14

[1]Warner-Bratzler shear force.