Muscle-How Much Do We Need To Optimize Carcass And Meat Characteristics

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Introduction

Historically, when steers were finished on pasture, ability to finish at a young age was desirable. Particularly when market requirements for fatness were great. However, ability to fatten became a handicap as we shifted to increased use of concentrate feeds in diets of growing-finishing cattle. Consequently, yield grades were added to the USDA grading system to reflect variation in carcass value associated with differences in yield of retail product. Recently, consumer pressure to reduce caloric and fat content of beef and other red meats has intensified because coronary heart disease is believed to be associated with elevated blood-cholesterol levels. Cholesterol levels are, in turn, associated with dietary intake of saturated fat. Dietary control of the type and amount of fat consumed is strongly recommended by members of the medical profession in an attempt to regulate blood-cholesterol levels. The purpose of this paper is to examine genetic variation among and within breeds in amount and distribution of muscle (lean) in beef carcasses, to evaluate opportunities to geneticly change leanness in beef carcasses, and to assess changes in other characteristics likely to result from selection among and within breeds for leanness and muscling in beef cattle.

Germ Plasm Evaluation Program

Most of my comments will be based on results from the Germ Plasm Evaluation (GEP) Program at the Roman L. Hruska U.S. Meat Animal Research Center (MARC). The GEP program is presently in the fourth cycle (Table 1). Topcross performance of 26 different sire breeds have been, or are being, evaluated in calves out of Hereford and Angus dams or calves out of F_1 cross dams. These F_1 cross dams were bred to Brahman, Devon and Holstein sires in Cycle I and to Santa Gertrudis and Brangus sires in Cycle II. Semen from the same Hereford and Angus bulls has been used throughout to produce a control population of Hereford-Angus reciprocal crosses in each cycle of the program. In addition to the repeated use of semen from control Hereford and Angus bulls, new samples of Hereford, Angus, and Charolais bulls born since 1982 are being added in Cycle IV to evaluate genetic trends within these breeds. Preliminary data are presented on genetic trends for growth and carcass and meat characteristics in Angus and Herefords from the first of five calf crops to be produced in Cycle IV. Most of my comments will be based on completed evaluations of twenty sire breeds involved in the first three cycles of the program. Data presented were pooled over Cycles I, II, and III by adding the average differences between Hereford-Angus reciprocal crosses (HAx) and other breed groups (2-way and 3-way F_1 crosses) within each Cycle to the average of Hereford-Angus reciprocal crosses (HAx) over the three cycles. Data will be presented for nineteen F_1 crosses (2-way and 3-way) grouped into seven biological types based on relative differences (X lowest, XXXXXX

Table 1. Sire Breeds Used In Germ Plasm Evaluation Program

Cycle 1 (1970-72)	Cycle II (1973-74)	Cycle III (1975-76)	Cycle IV (1986-90)
F1 crosses from Hereford or Angus dams (Phase 2)			
Hereford	Hereford	Hereford	Hereford[a]
Angus	Angus	Angus	Angus[a]
Jersey	Red Poll	Brahman	Longhorn
S. Devon	Brown Swiss	Sahiwal	Salers
Limousin	Gelbvieh	Pinzgauer	Galloway
Simmental	Maine Anjou	Tarentaise	Nellore
Charolais	Chainina		Shorthorn
			Piemontese
			Charolais
			Gelbvieh
			Pinzgauer
3-way crosses out of F1 dams (Phase 3)			
Hereford	Hereford		
Angus	Angus		
Brahman	Brangus		
Devon	Santa Gertrudis		
Holstein			

[a] Hereford and Angus sires, originally sampled in 1969, 1970, and 1971, have been used throughout the program. In Cycle IV, a new sample of Hereford and Angus sires produced after 1982 are being used and compared to the original Hereford and Angus sires.

highest) in growth rate and mature size, lean to fat ratio, age at puberty and milk production (Table 2). The carcass and meat data, obtained in cooperation with Kansas State University under the direction of Dr. Micheal E. Dikeman, are presented for 15 F^1 crosses out of Hereford and Angus dams (Koch et al., 1976,1977,1979, 1981, 1982b, 1982c).

Variation Between and Within Breeds

Retail Product

Throughout the GPE program, we have obtained closely trimmed-boneless retail product, i.e., steaks and roasts (trimmed to .3 in of external fat and boneless except for the short loin and rib roasts) and lean trim (trimmed and processed into ground beef with 25% fat content based on chemical analysis). Recently, in the GPE program we have obtained data on retail product with two levels of trim. After weights for closely trimmed retail product from each wholesale cut are recorded, retail cuts are trimmed to 0 in outside fat and are made entirely boneless. The fat trim removed between the closely trimmed (.3 in) and zero trimmed(.0 in) accounted for 4.6% of the side weight of yield grade

Table 2. Breed Crosses Grouped Into Six Biological Types On The Basis Of Four Major Criteria[a]

Breed Group	Growth Rate & Mature Size	Lean to Fat Ratio	Age To Puberty	Milk Production
Jersey	X	X	X	XXXXX
Hereford-Angus	XX	XX	XXX	XX
Red Poll	XX	XX	XX	XXX
Devon	XX	XX	XXX	XX
South Devon	XXX	XXX	XX	XXX
Tarentaise	XXX	XXX	XX	XXX
Pinzgauer	XXX	XXX	XX	XXX
Brangus	XXX	XX	XXXX	XX
Santa Gertrudis	XXX	XX	XXXX	XX
Sahiwal	XX	XXX	XXXXX	XXX
Brahman	XXXX	XXX	XXXXX	XXX
Brown Swiss	XXXX	XXXX	XX	XXXX
Gelbvieh	XXXX	XXXX	XX	XXXX
Holstein	XXXX	XXXX	XX	XXXXXX
Simmental	XXXXX	XXXX	XXX	XXXX
Maine Anjou	XXXXX	XXXX	XXX	XXX
Limousin	XXX	XXXXX	XXXX	X
Charolais	XXXXX	XXXXX	XXXX	X
Chianina	XXXXX	XXXXX	XXXX	X

[a]Increasing number of X's indicate relatively higher levels of performance on older age at puberty.

Table 3. Heritability Estimates For Retail Product Yields

Source	Retail Product Weight	Retail Product Percentage
Cundiff et al., (1964)		.40[a]
Swinger et al., (1965)	.65	.24
Cundiff et al., (1969,1971)	.64	.28
Dinkel and Busch (1973)	.38	.66[a]
Koch (1978)	.38	
Benyshek (1981)	.55	.49[a]
Koch et al. (1982a)	.58	.63
Average	.53	.45

[a] Cutability: Estimated percentage of retail product from the round, loin, rib, and chuck.

1 cattle and 5.3, 5.5 and 5.5% of the side weight of yield grades 2, 3 and 4 cattle, respectively (Crouse et al., 1988). Thus, there is a high degree of association between closely trimmed and zero trimmed retail product, especially in cattle of yield grades 2, 3, and 4. In this presentation variation in growth and distribution of muscle will be assessed as reflected by variation in growth and distribution of closely timmed retail product.

The genetic variation that exists in proportions of muscle and fat of beef carcasses is vast and under a high degree of genetic control. The variation observed among steers of the same breed which are fed and managed under uniform conditions and compared at the same slaughter age is highly heritable for both weight and percentage of retail product (Table 3).

Results for retail product growth to 458 days of age are summarized in Figure 1. Means are shown on the lower horizontal axis for F_1 crosses. The spacing on the vertical axis is arbitrary but the ranking of biological types (separate bars) from the bottom to top reflect, generally, increasing increments of mature size. Breed rankings within each biological type are noted within each bar. Steers sired by bulls of breeds with larger mature size produced significantly more retail product than steers sired by bulls of breeds with small mature size.

In Figure 1, differences are doubled in the upper horizontal scale to reflect variation among pure breeds relative to a standard deviation change in breeding value $[\sigma g\_ \ (\sigma^2 p) \ (h^2)]$ within pure breeds for weight of retail product at 458 days of age (Cundiff et al., 1986). Frequency curves, shown for Jersey, the average of Hereford and Angus, and Chianina, reflect the distribution expected for breeding values of individual animals within pure breeds assuming a normal distribution (i.e., 68, 95 or 99.6% of the observations are expected to lie within the range bracketed by the mean $\pm$ 1, 2, or 3 standard deviations, respectively). The breeding value of the heaviest Jersey is not expected to equal that of the lightest Chianina and heaviest Hereford and Angus would only equal the lightest Chianina in genetic potential for retail product growth to 458 days. The range for mean differences between breeds is estimated to be about 5.7 σg between Chianina and Hereford or Angus steers and about 8.2 σg between Chianina and Jersey steers. Genetic variation, both between and within breeds is considerable for this important measure of output. When both between and within breed genetic variations are considered, the range in breeding value from the smallest Jersey steers to the heaviest Chianina steers is estimated to be 180 kg, or 88% of the overall mean. About half of the variation among breeds in retail product at 458 days of age is associated with variation in carcass weight and half is associated with composition or percentage of the carcass accounted for by retail product.

In general, breeds that excel in growth of total carcass weight also excel in percentage of retail product (Figure 2). This raises the question, has selection for growth to weaning or yearling ages within breeds had a favorable effect on percentage of retail product? Preliminary estimates of genetic trends in the Hereford and Angus breeds

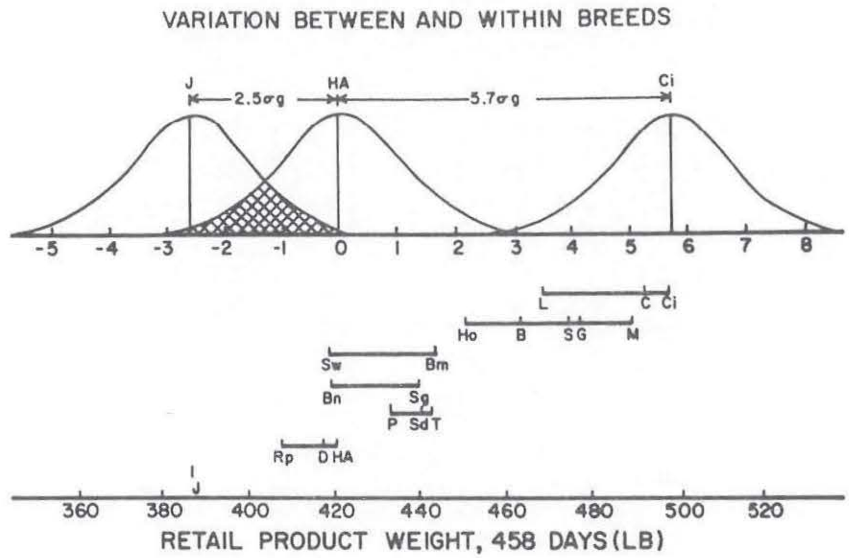

Figure 1. Breed group means (F_1 crosses, lower axis) and genetic variation between and within breeds (σg, standard deviation in breeding value, upper axis) for weight of retail product at 458 days (Adapted from Cundiff et al., 1986). See Table 2 for abbreviations.

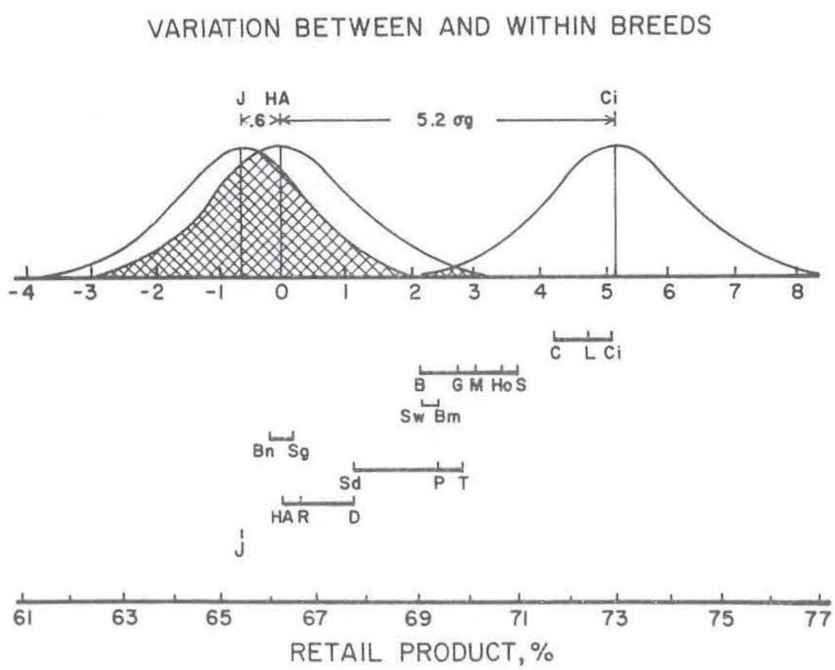

Figure 2. Breed group means (F_1 crosses, lower axis) and genetic variation between and within breeds (σg, standard deviation in breeding value, upper axis) for retail product as a percentage of carcass weight at 458 days of age (Adapted from Cundiff et al., 1986). See Table 2 for abbreviations.

are reflected in Table 4, comparing progeny of 17 Hereford bulls (9 polled and 8 horned) and 15 Angus bulls sampled broadly and born since 1982 to 11 Herefords and 14 Angus produced in the late 1960's and used throughout the GPE Program. The preliminary nature of these results must be emphasized because they are based on just the first of five calf crops being produced in Cycle IV of the GPE Program. Indications are that significant change from growth to slaughter ages has accrued in both Herefords and Angus between the late 1960's and the early 1980's. This was expected in view of the selection emphasis that seedstock

Table 4. Genetic Change in Hereford and Angus Breeds in Final Weight and Carcass Characteristics As Reflected By Progeny of Bulls Born In Late 1960's (Original) Versus Progeny of Bulls Born In Mid 1980's (Current)[a]

Breed Group	No. Steers	Final Weight lb	Dress Percent %	USDA Choice %
Hereford Sires				
Original	38	1056	61.0	75.6
Current	35	1091	60.6	44.7
Angus Sires				
Original	32	1056	61.3	77.0
Current	30	1096	61.0	78.0

Breed Group	Est. Cut. %	Fat Thick-ness in	Rib Eye Area Sq in	Kidney Pelvic & Heart Fat %
Hereford Sires				
Original	49.4	.51	10.55	2.5
Current	49.3	.48	10.23	2.6
Angus Sires				
Original	49.3	.47	10.79	3.0
Current	49.3	.48	10.74	2.7

[a]Preliminary results from first of five calf crops produced in Cycle IV of Germ Plasm Evaluation Program at the Roman L. Hruska U.S. Meat Animal Research Center, Data are averaged over Hereford and Angus dams.

breeders in both of these breeds have placed on growth rate and skeletal size during this period. However, indications to date, are that carcass composition has not changed significantly in cattle compared at the same age. Estimates for fat thickness and estimated cutability (retail product from round, loin, rib and chuck expressed as a percentage of carcass weight) are about the same for progeny of original sires as for progeny of current sires in both breeds. These results indicate that selection for weight and skeletal size will not significantly change carcass composition. This result is consistent with previous estimates of genetic trends which have been predicted on the basis of estimates of heritability and genetic correlation found within breeds (Cundiff et al., 1969; Koch et al., 1982a). Selection within breeds can effectively change rate and composition of growth, but some direct selection pressure must be applied against fatness at the same time that live weight is considered in order to change composition of growth.

Distribution of Retail Product

An evaluation of differences in distribution of retail products, bone and fat trim among the round, loin, rib, chuck and minor cuts (shank, brisket, plate and flank) showed little variation in muscle and bone distribution (Figure 3). Again, this result is consistent with findings that the genetic correlations between retail product yield in one cut are highly correlated with that in other cuts and that selection to shift the distribution of muscle from lower valued cuts to higher valued regions of the carcass would be ineffective (Cundiff et al., 1969). Even among breeds as diverse as Jersey and Charloais, there is little opportunity to shift muscle as a proportion of carcass weight from one cut into another. Similar results have been found between Bos indicus and Bos taurus breeds evaluated by Australian scientists (Berg and Butterfield, 1976).

Antagonistic Relationships

With so much genetic variation between breeds for retail product growth to a constant age (Figure 1), it is valid to ask why hasn't more been done to exploit this variation. In dairy production in the United States, Holsteins which excel in fluid milk yield have replaced the vast majority of cows of other breeds with lower genetic potential for fluid milk yield. It is estimated that Holsteins produce 90% of the milk marketed in the United States. In beef production in the United States, breeds that excel in output of retail products have not been substituted nearly to this extent for those with lower output potential--Why? In part, the answer lies in trade-offs resulting from antagonistic genetic relationships between retail product growth and other traits important to efficiency of beef production. Antagonistic relationships between retail product growth and other characteristics will be discussed in other contributions to the proceedings of this conference. In this paper, only the relationships between retail product growth and other carcass characteristics will be emphasized.

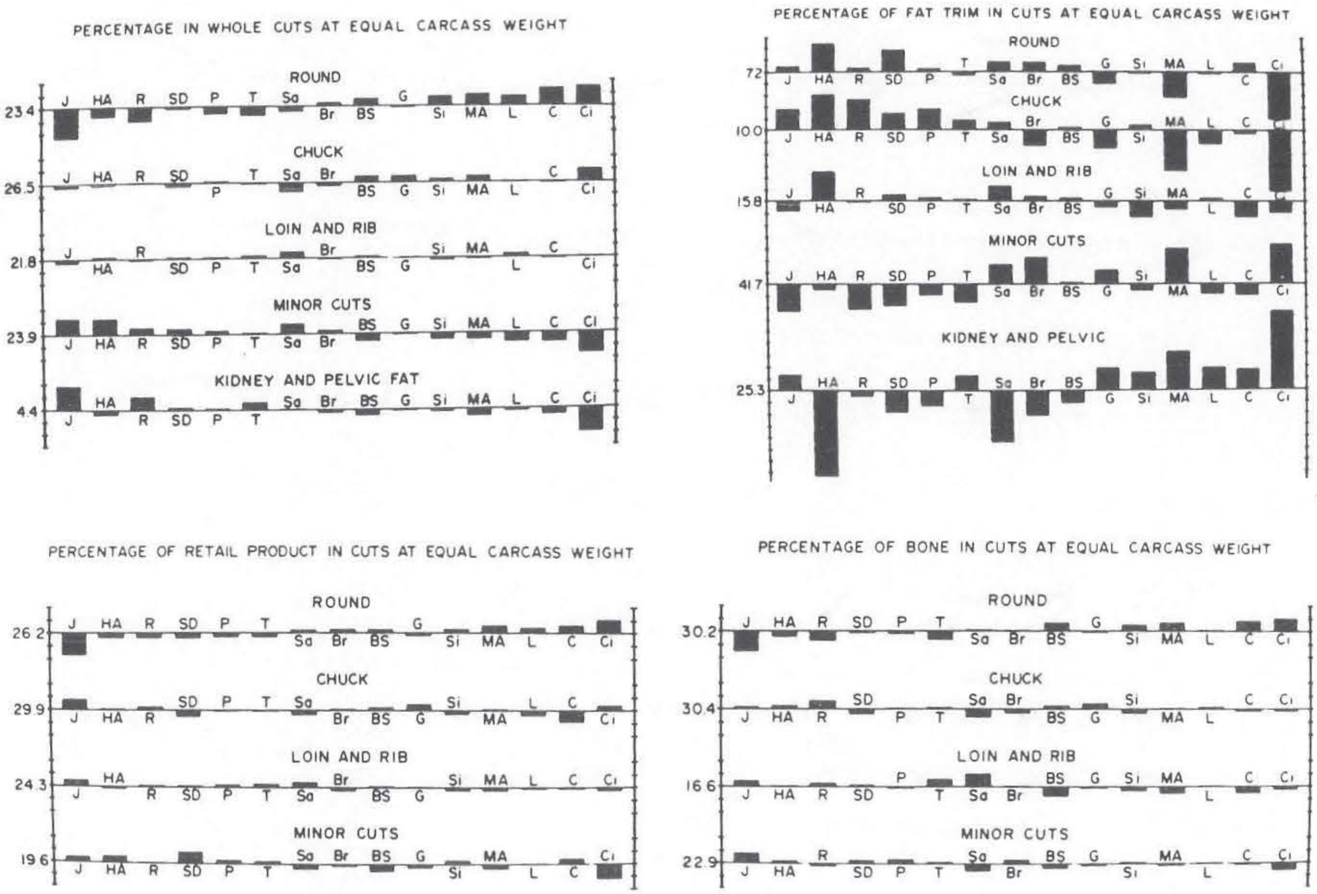

Figure 3. Percentage of carcass in wholesale cuts and percentage of total retail product, fat trim and bone in each cut at an equal carcass weight (Adapted from Koch, et al., 1977, 1981, 1982b). See Table 2 for abbreviations.

Marbling

Degree of marbling (i.e., deposits of fat interspersed in muscle) in the twelfth rib cross-section of the rib eye muscle is currently the primary determinant of USDA quality grade among carcasses of cattle of the same age. Traditionally, marbling has been emphasized because it was believed to be associated with palatability characteristics of meat. Some studies have shown a positive relationship between marbling and palatability characteristics, especially sensory panel ratings for tenderness or Warner-Bratzler shear force, while other have shown a very low or nonexistent relationship (Smith et al., 1984).

Significant genetic variation exists between and within breeds for propensity to deposit marbling (Figure 4). Again, the range for differences between breeds is about equal to the range for breeding value of individual animals within breeds for marbling. Within breeds, variation in marbling was highly heritable (.40). However, it is much easier to use information on variation among breeds than within breeds for marbling because of the difficulty of measuring marbling levels in live bulls and heifers used for breeding. Also, heritability of breed differences is high (approximately 100%), provided the breed means are estimated with an adequate sample to average out errors of sampling individual animals within breeds. The tendency for progeny from individual animals to regress to their own breed group mean is much greater than any tendency to regress to the mean of all cattle.

Unfortunately, breeds that rank highest for retail product percentage rank lowest for marbling (Figure 5). Similarly, high negative genetic correlations have been found within breeds between marbling and retail product percentage. Thus, only limited opportunity exists from between breed selection or from within breed selection for genetically increasing marbling without increasing fat trim and reducing retail product percentage. This antagonistic relationship between retail product percentage and marbling, or between USDA yield grade and USDA quality grade has deterred the substitution of breeds to those that excel in leanness and yield grade from those with lower yield grades but higher USDA quality grades.

Marbling and Palatability

Concern with the antagonism between marbling and retail product percentage is justified to the extent that a certain amount of marbling is required to insure palatability of the retail product. Sensory panel evaluations of uniformly cooked 10th rib steaks from about 1,230 steers produced in the GPE program are summarized in Table 5. High levels of acceptance were found for steaks from all Bos taurus breed groups when the steers were fed and managed alike and slaughtered at 14 to 16 months of age. In these studies, sensory scores were assigned on a 9 point scale from 1 = extremely undesirable (e.g., extremely tough), 5= acceptable, up to 9 = extremely desirable (e.g., extremely tender). Average taste panel scores and Warner-Bratzler shear determinations for tenderness did tend to improve as marbling increased when comparisons were at the same age but, the change was very small. Although, breed groups differed significantly in average marbling scores and in percentage of carcasses that had adequate marbling to grade USDA Choice or better, average sensory panel evaluations of tenderness, flavor and juiciness were acceptable for all breed groups.

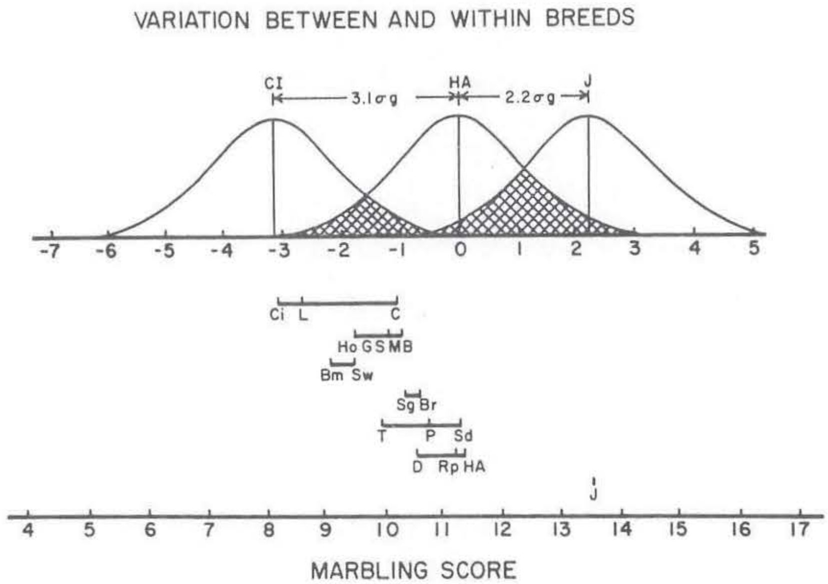

Figure 4. **Breed group means (F_1 crosses, lower axis) and genetic variation between and within breeds (σg, standard deviation in breeding value, upper axis) for marbling score (5 = traces, 8 = slight, 11 = small, 14 = modest) at 458 days of age (Adapted from Cundiff et al., 1986). See Table 2 for abbreviations.**

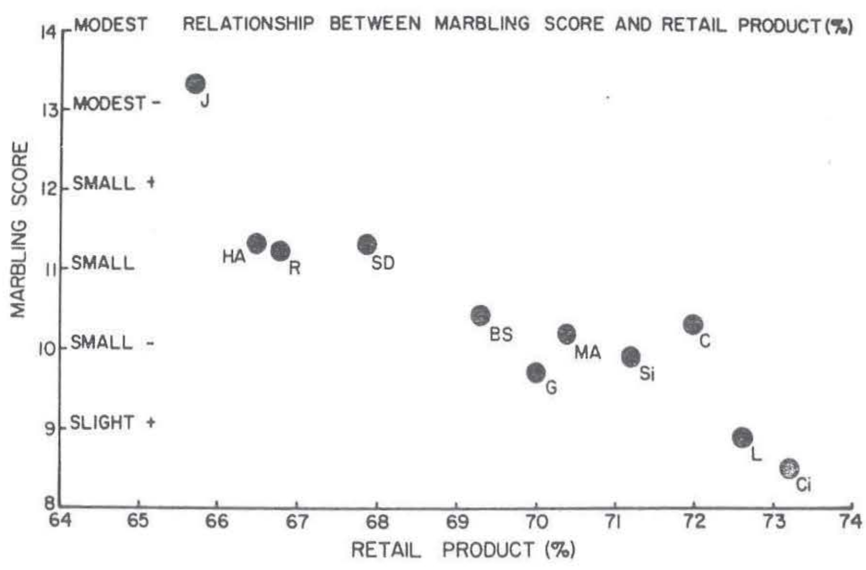

Figure 5. **Breed group means for retail product percentage versus marbling score at 458 days of age (Adapted from Koch et al., 1976, 1979, 1982c). See Table 2 for abbreviations.**

Table 5. Breed Group Means for Factors Identified With Meat Quality

Breed Crosses	Marb-ling	Percent USDA Choice	Warner-Bratzler shear[b] (lb)
Chianina-X	8.3	24	7.9
Limousin-X	9.0	37	7.7
Brahman-X	9.3	40	8.4
Gelbvieh-X	9.6	43	7.8
Sahiwal-X	9.7	44	9.1
Simmental-X	9.9	60	7.8
Maine-Anjou-X	10.1	54	7.5
Tarentaise-X	10.2	60	8.1
Charolais-X	10.3	63	7.2
Brown Swiss-X	10.4	61	7.7
Pinzgauer-X	10.8	60	7.4
South Devon-X	11.3	76	6.8
Hereford-Angus-X	11.3	76	7.3
Red Poll-X	11.5	68	7.4
Jersey-X	13.2	85	6.8

Breed Crosses	Sensory Panel Score[c]		
	Flavor	Juici-ness	Tender-ness
Chianina-X	7.3	7.2	6.9
Limousin-X	7.4	7.3	6.9
Brahman-X	7.2	6.9	6.5
Gelbvieh-X	7.4	7.2	6.9
Sahiwal-X	7.1	7.0	5.8
Simmental-X	7.3	7.3	6.8
Maine-Anjou-X	7.3	7.2	7.1
Tarentaise-X	7.3	7.0	6.7
Charolais-X	7.4	7.3	7.3
Brown Swiss-X	7.4	7.2	7.2
Pinzaguer-X	7.4	7.2	7.1
South Devon-X	7.3	7.4	7.4
Hereford-Angus-X	7.3	7.3	7.3
Red Poll-X	7.4	7.1	7.3
Jersey-X	7.5	7.5	7.4

[a] Marbling: 8 = slight, 11 = small, 14 = modest, 17 = moderate.
[b] Shear force required for a 1 in. core of cooked steak.
[c] Taste panel scores: 2 = undesirable, 5 = acceptable, 7 = moderately desirable, 9 = extremely desirable.

However, variation in sensory panel tenderness scores (see standard deviations, Table 6) tends to be greater in cattle with low levels of marbling than in cattle with high levels of marbling (Koch et al., 1988). This in turn leads to greater risk of at least some steaks having less than acceptable tenderness at low levels of marbling. In Bos taurus sired cattle with a slight degree of marbling (USDA Select), 3% of the steaks were scored as less than acceptable (sensory panel scores of <5) in tenderness. In Bos taurus sired cattle with moderate or greater degrees of marbling (USDA high choice or Prime), 0% of the steaks were scored as less than acceptable (i.e., 100% had scores $\geq$ 5). Sensory panel scores for steaks from Bos indicus sired steers were lower for tenderness than those from Bos taurus sired steers, even at the same degree of marbling.

Caloric Density of Retail Product

Dairy processors have developed and effectively marketed products with a similar range in caloric content to that found between Chianina and Jersey steers. Low fat milk (2% fat content) contains 20% fewer calories per one cup serving than regular milk (3.5% fat content). Similar ranges can be achieved in beef products by fabrication and marketing of totally-trimmed retail cuts. The key to production of low calorie beef products is total trimming. Fat contains 225 calories per ounce. Caloric content of totally-trimmed beef varies depending on the level of intramuscular fat (marbling) in the lean. Composition and estimates of caloric content in 1 oz portions of uncooked longissimus (rib-eye) muscle with different USDA quality grades and degrees of marbling are shown in Table 7. Muscle with a slight degree of marbling (USDA Select quality grade) is about 3.7% fat and contains about 40 kcal per ounce. Muscle from carcasses grading USDA Choice range from about 4.7 to 9.3% fat and contain about 43 to 51 kcal per ounce. Muscle from carcasses in the USDA Prime grade range from about 9.2 to 12.7% fat and contain 52 to 60 kcal per oz.

Breed group means for calories originating from the lean, intra-muscular fat, and inter-muscular fat components of 100 gram (3.5 oz) uncooked portions of retail product are presented in Table 8. External and inter-muscular fat (averaging 20.6% over all breeds) accounted for a much greater proportion of total fat in the retail product than intra-muscular (i.e., marbling) fat (averaging 4.0%). Variation among breeds was important for both percentage of external and intra-muscular fat (range 2.6 percentage units) and for percentage of inter-muscular fat (range of 3.2%). On the average, a 100 g portion of uncooked retail product containing a total of 280 kcal, would have 83 kcal originated from protein (29.7%), 34 kcal originated from intra-muscular fat (12.2%) and 163 kcal originated from external and inter-muscular (58.3%). Caloric content of retail products is markedly reduced by total trimming of visible fat. Total trimming will obviously favor production of carcasses with a higher percentage of retail product and less fat trim. Caloric content of totally-trimmed portions (lean and intra-muscular fat only) contained an average of 117 kcal. For totally-trimmed retail product, the range among F_1 breed groups was 14 kcal (111 for Chianina crosses to 125 kcal for Jersey crosses). Since topcross comparisons estimate only half of the difference between breeds, estimates of the range between F_1 crosses can be doubled to estimate the range between pure breeds--28 kcal or from about 99 kcal for Chianina to 127 kcal for Jersey steers.

Table 6. Effects of Marbling on Sensory Panel Tenderness in *Bos Taurus* and *Bos Indicus* Crosses (Koch et al., 1988)[a]

Bos taurus sired[b]				
Marbling degree	No. steers	Average score	Standard dev.	Score less than acceptable (<5,%)
P. Devoid	3	5.1	1.2	66.7
Traces	68	6.7	1.1	10.3
Slight	362	7.0	.9	3.0
Small	389	7.3	.8	1.3
Modest	161	7.4	.8	1.9
Moderate	59	7.7	.6	0
Sl. Abundant	24	7.8	.5	0
Md. Abundant	8	7.4	.8	0
Abundant	5	8.1	.5	0

Bos indicus sired[c]				
Marbling score	No. steers	Average score	Stand. dev.	Score less than acceptable (<5,%)
P. Devoid				
Traces	20	5.7	1.1	15.0
Slight	61	5.8	1.3	24.6
Small	50	6.5	1.2	10.0
Modest	10	6.5	1.0	10.0
Moderate				
Sl. Abundant	1	7.7		0
Md. Abundant				
Abundant				

[a] Sensory panel scores for tenderness ranged form 1 = extremely tough, 5 = acceptable, 9 = extremely tender.
[b] Angus, Brown Swiss, Charolais, Chianina, Gelbvieh, Hereford, Jersey, Limousin, Maine Anjou, Pinzagaur, Red Poll, Simmental, South Devon and Tarentaise sired topcrosses out of Hereford and Angus dams produced on Cycles I, II and III of the Germ Plasm Evaluation Program.
[c] Brahman and Sahiwal sire topcrosses out of Herefords and Angus dams produce in Cycle III of the Germ Plasm Evaluation Program.

Table 7. Composition and Caloric Content of L. Dorsi (Rib Eye) Muscle With different Degrees of Marbling (1 oz Uncooked Portion)

Quality grade	Marbling	Chem. fat[a] %	kcal	Protein[b] %	kcal	Total kcal
	Fat free	0	0	27.0	31.5	31.5
Standard	Practically devoid	.7	1.9	26.8	31.3	33.1
Standard	Traces	2.2	5.8	26.4	30.7	36.5
Good	Slight	3.7	9.8	26.0	30.2	40.0
Choice	Small	5.2	13.7	25.6	29.6	43.4
Choice	Modest	6.7	17.8	25.2	29.1	46.8
Choice	Moderate	8.2	21.7	24.8	28.5	50.2
Prime	Slightly abundant	9.7	25.7	24.4	27.9	53.6
Prime	Moderately abundant	11.2	29.7	24.0	27.4	57.1
Prime	Abundant	12.7	33.7	23.6	26.8	60.5

[a] Chemical fat, % = - .3 + .5(M) where M = 5 for traces, 8 for slight, ..., and 17 for moderate degrees of marbling (Campion et al., 1975) and fat contains 9.3 kcal per gram (Ganong, 1977).

[b] Lean is 27% protein (NAS, 1967) and protein contains 4.1 kcal per gram (Ganong, 1977).

Table 8. Breed group (F_1 Cross) Means for Caloric Content of Retail, 100 g (3.5 oz) Uncooked Portion (Cundiff,1986)

Breed group	Lean protein kcal	intra-musc. fat kcal	inter-musc. fat kcal	Total kcal	Lean and intra-musc. fat only kcal
Jersey-X	79	46	180	305	125
Hereford-Angus-X	81	42	172	294	123
Red Poll-X	80	40	177	297	120
South Devon-X	82	39	167	287	121
Tarentaise-X	84	33	159	276	117
Pinzgauer-X	83	39	160	281	122
Sahiwal-X	84	30	161	275	114
Brahman-X	84	30	164	276	113
Brown Swiss-X	83	32	164	280	116
Gelbvieh-X	84	33	160	277	117
Simmental-X	84	33	156	273	117
Maine Anjou-X	83	32	164	280	115
Limousin-X	86	26	154	266	111
Charolais-X	84	33	156	274	117
Chianina-X	86	25	155	265	111
Range (R)	7	21	26	40	14

Significant opportunity exists to breed and produce cattle which will provide for two types of beef: 1) lean beef that is low in fat and caloric content more suited to customers seeking to limit dietary intake of saturated fats, and 2) highly marbled beef that is well suited to the gourmet food trade where customers are most concerned about the risk of serving or consuming an occassional steak with less than acceptable tenderness than they are about risk of consuming too much fat.

Conclusion

The variation that exists in biological traits of economic importance to beef production, including carcass leanness, is vast and under a high degree of genetic control. Genetic variation found between breeds is comparable in magnitude to that found within breeds for most growth and carcass traits. Thus, significant genetic change can result from selection both between and within breeds.

Between breed differences are more easily exploited than genetic variation within breeds because they are more highly heritable. Also, use of genetic variation within breeds is complicated by difficulties of estimating carcass characteristics in live animals used for breeding or by the increased generation interval and other costs associated with progeny testing.

Even though large differences exist among breeds in shape of muscle, there is little variation among breeds in distribution of muscle systems (e.g., Jersey and Limousin crosses do not differ in percentage of retail product contributed by the loin and rib).

The genetic variation both between and within breeds can be used to provide an array of beef products that differ widely in fat and caloric content. Cattle with the greatest retail product growth potential produce carcasses with lower levels of marbling and totally-trimmed retail cuts with lower fat and caloric content. These cattle are especially well suited for marketing opportunities for low fat or low caloric beef with acceptable palatability characteristics. Cattle with greater marbling potential are more suited to marketing opportunities for the gourmet food trade where the risk of occasional steaks with unacceptable tenderness must be minimized.

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