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Introduction

Crossbreeding is used widely to exploit heterosis and additive genetic variation among breeds to improve efficiency of beef production. The economic value of *Bos indicus* breeds of cattle, primarily Brahman, in crossbreeding programs in subtropical and tropical climates has been well established. In the temperate climatic conditions of MARC, productivity of *Bos indicus* x *Bos taurus* F_1 crossbred cows has been outstanding for reproduction and maternal performance relative to that of *Bos taurus* x *Bos taurus* F_1 cross cows when mated to produce terminal-cross calves by Red Poll or Simmental sires. (Brahman and Sahiwal are *Bos indicus* [humped] breeds; Pinzgauer, Angus, Hereford, Red Poll and Simmental and other European breeds are *Bos taurus* [nonhumped] breeds).

Palatability and leanness are important characteristics of beef that influence consumer demand. Tenderness is the dominant palatability attribute considered by consumers in determining meat acceptability. Previous research has shown that meat from *Bos indicus* breeds or crosses was less tender than meat from *Bos taurus* breeds or crosses of cattle. The objective of the research reported here was to determine the effects of 0, 25, 50 or 75% *Bos indicus* (Brahman or Sahiwal) inheritance on characteristics of carcasses and palatability of cooked meat.

Procedure

Carcass and meat traits of 422 steers differing in the ratio of Brahman (B), Sahiwal (S) or Pinzgauer (P) to Angus (A) or Hereford (H) inheritance were studied. Reciprocal backcross and F_2 matings (Table 1) provided calves with 0:100, 25:75; 50:50 and 75:25 ratios of Pinzgauer, Brahman and Sahiwal to Angus-Hereford inheritance. The steers were born in the spring of 1983, 1984, 1985 and 1986 in Cycle III of the Germplasm Evaluation (GPE) Program at MARC. After weaning in early October, steers were fed a growing ration until February. Subsequently they were fed, ad libitum, a mixed diet of corn silage, corn and soybean meal ranging in energy density from 2.74 Mcal of metabolizable energy per kg of dry matter early in the finishing period to 2.93 Mcal of metabolizable energy per kg of dry matter late in the finishing period.

The steers were slaughtered serially at two slaughter dates each year (avg interval was 40 days). All steers were about 13 to 15 mo of age at slaughter. After a 24 hr chill, carcasses were evaluated for USDA (1976) quality and yield grade criteria. Ribs were removed 24 hr postmortem, vacuum packaged, aged an additional 6 days at 34°F, frozen at -22°F and stored for up to 6 mo for subsequent shear force and sensory evaluation. An eight-member sensory panel was trained and tested. Panelists, in individual booths, evaluated three .5 in cubed samples for juiciness, ease of fragmentation, amount of connective tissue, overall tenderness, flavor intensity and off-flavor.

Results

Carcass traits. Least squares means for final live wt and carcass traits for each of the 10 breed groups are given in Table 1. As expected from earlier phases of the experiment, Pinzgauer crosses were the heaviest (avg of all Pinzgauer crosses = 1122 lb), followed by Angus-Hereford crosses (1049 lb). The *Bos indicus* breed crosses were the lightest (avg of all Brahman crosses = 1014 lb; Sahiwal = 921). Results for wt are in contrast with results from the previous phase of the GPE program in which F_1 cross steers by Brahman sires were significantly heavier (87 lb) than F_1 Angus-Hereford cross steers. The sires used in the present study were the same as those used in the previous phase of the GPE program. Thus, a large portion of the increased wt advantage of the F_1 Brahman x Angus or Hereford may have been due to at least twice as much heterosis in *Bos indicus* x *Bos taurus* crosses as in *Bos taurus* x *Bos taurus* crosses, which has previously been reported by scientists in Texas (Cartwright and associates) and Florida (Koger and associates). The backcross and F_2 progeny in the present phase of the experiment are expected to have only half as much heterosis as that observed in the F_1 crosses. Thus, in backcross and F_2 matings, *Bos indicus* x *Bos taurus* crosses stand to lose at least twice as much from their heterosis effect as *Bos taurus* x *Bos taurus* crosses. These results suggest that heterosis effects, rather than additive gene effects, accounted for the superior growth observed earlier in F_1 crosses.

The Angus-Hereford crosses had the greatest fat thickness. Ribeye areas of Angus-Hereford crosses were similar to those of Brahman or Sahiwal crosses. The Pinzgauer breed crosses had the largest ribeye areas and least fat thickness. Percentage of *Bos indicus* had no consistent effect on fat thickness or ribeye area. *Bos indicus* crosses possessed a lower percentage of kidney, pelvic and heart fat than *Bos taurus* breed crosses.

The Angus-Hereford breed crosses had the greatest amount of marbling, followed by Pinzgauer crosses. *Bos indicus* crosses possessed the smallest amount of marbling, but the Brahman and Sahiwal crosses were similar to each other in marbling. Generally, marbling decreased as the percentage of *Bos indicus* inheritance increased.

Shear Force and Palatability Traits. Breed group avg of shear values and sensory panel scores are given in Table 2. Also, shear values greater than 6.95 (overall avg + 1 standard deviation) expressed as a percentage of the number of observations within each breed group are shown in Table 2. Significant variation among breed groups was observed in shear values, sensory panel ease-of-fragmentation scores, sensory panel perception of the amount of connective tissue and overall tenderness. Meat was observed to be similar for juiciness, intensity of beef flavor and off-flavor among breed groups.

Shear values increased and sensory panel estimates of tenderness decreased with increases in percentage of *Bos indicus* inheritance. Shear force required to slice through half inch cores of cooked rib steaks increased 1.6 lb for each 25% increase in Brahman inheritance and 2.9 lb for each 25% increase in Sahiwal inheritance. Sensory panel

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estimates of tenderness decreased linearly as Brahman or Sahiwal germplasm was substituted for Angus or Hereford germplasm.

Separate analyses of variance and standard deviation for each breed group revealed that as the percentage of *Bos indicus* inheritance increased, within breed group variation in shear values increased. Standard deviations for shear were 2.2, 2.5, 2.6, and 4.7 lb for steers with 0, 25, 50 and 75% Brahman inheritance and 2.2, 3.7, 4.1, and 4.8 lb for steers with 0, 25, 50 and 75% Sahiwal inheritance, respectively. A similar trend was also noted for variation in sensory panel scores, especially in Brahman crosses. Percentage of Pinzgauer inheritance had no consistent effect on variation in shear values or overall tenderness.

The increased variation in shear and sensory panel tenderness scores resulted in increased percentages of shears greater than 15.3 lb and of sensory panel scores for tenderness of less than 4.6. Sensory panelists gave 41.2% of the meat from *Bos indicus* crossbreds tenderness scores of less than or equal to 4.62. As the percentage of Brahman or Sahiwal inheritance increased, the percentage of tenderness scores in the lower end of the scale increased. For 3/4 Sahiwal breed group, 85.7% of the tenderness scores fell within this range of the scale. Sensory panel scores for ease-of-fragmentation and amount of connective tissues also were less desirable as the percentage of *Bos indicus* inheritance increased. Percentage of Pinzgauer breeding had no effect on the tenderness observations, but shear values for Pinzgauer were greater than those for the Angus-Hereford cross group. Sensory panel scores for juiciness also decreased as the percentage of *Bos indicus* inheritance increased. Neither beef flavor nor off-flavor was affected by breed groups.

Implications. Obvious problems of tenderness exist in *Bos indicus* breeds of cattle. These problems seem to be independent of the environment in which animals were produced or composition of the meat. Problems associated with palatability must be solved before *Bos indicus* breeds of cattle can be used to optimize production efficiency in breeding programs without consideration of the negative impact of *Bos indicus* inheritance on meat palatability. Data reported here indicate that the tenderness problem probably is related to fragmentation of the muscle component of lean and, to a lesser extent, to theconnective tissue portion of lean. The biological basis of the variation in tenderness associated with *Bos indicus* breeds of cattle needs to be determined before solutions are likely to be found. In the mean time, breeding systems which optimize the *Bos indicus* influence at levels of about 50% in tropical environments (e.g., gulf coastal region) and about 25% percent in more subtropical to temperate environments are recommended to optimize performance levels for reproduction, maternal performance and other components of production efficiency and to more nearly match genetic potential to market requirements for beef with acceptable levels of tenderness.

Table 1—Carcass trait means for breed groups differing in ratios of Pinzgauer (P), Brahman (B) and Sahiwal (S) to Angus-Hereford (AH) inheritance

Breed group[a]	No.	Live wt lb	Carcass wt lb	Marbling score[b]	Fat thickness in.	Ribeye area sq. in.	Kidney, pelvic & heart fat
0:100 AH	107	1049	648	431	.57	10.80	3.0
25:75 P:AH	36	1120	687	421	.50	10.50	3.0
50:50 P:AH	44	1082	659	374	.37	11.80	2.8
75:25 P:AH	36	1164	701	366	.29	12.32	3.0
25:75 B:AH	28	1043	643	393	.47	10.82	2.9
50:50 B:AH	36	976	608	351	.43	10.62	2.8
75:25 B:AH	20	1022	633	306	.45	10.87	2.6
25:75 S:AH	35	1018	630	377	.42	11.07	2.7
50:50 S:AH	25	902	556	347	.42	10.23	2.8
75:25 S:AH	28	844	518	343	.37	10.00	2.6

[a] 0:100 AH denotes Angus (A) and Hereford (H) reciprocal backcross (HxAH, HxHA, AxAH, AxHA) and F_2 (F_1 x F_1 = AHxAH, HAxAH, AHxHA, HAxHA) progeny; Pinzgauer (P) breed groups include 25:75 backcross (AxPA, HxPH), 50:50 F_2 (PAxPA, PHxPH), and 75:25 backcross (PxPA, PxPH) progeny; Brahman (B) breed groups include 25:75 backcross (AxBA, HxBH), 50:50 F_2 (BAxBA, BHxBH), and 75:25 backcross (BxBA, BxBH) progeny; and Sahiwal (S) breed groups include 25:75 backcross (AxSA, HxSH), 50:50 F_2 (SAxSA, SHxSH), and 75:25 backcross (SxSA, SxSH) progeny.

[b] Marbling scored 300 through 399 = slight corresponds to USDA Select quality grade, and 400 through 499 = small corresponds to lowest one-third of the USDA Choice quality grade.

Table 2—Means for shear values and sensory panel scores of cooked ribeye steak samples from breed groups differing in ratios of Pinzgauer (P), Brahman (B), and Sahiwal (S) to Angus-Hereford (AH) inheritance

Breed group[a]	Shear		Sensory panel scores[c]						
						Tenderness			
	mean lb	>15.3[b] %	Juiciness	Ease of fragmentation	Connective tissue	mean	<4.6 %	Flavor intensity	Off flavor[d]
0:100 AH	9.7	1	5.2	5.4	5.2	5.4	6	5.0	2.8
25:75 P:AH	11.0	1	5.3	5.2	5.1	5.2	1	4.9	2.7
50:50 P:AH	11.3	4	5.2	5.3	5.1	5.3	2	5.0	2.8
75:25 P:AH	10.5	1	5.1	5.3	5.2	5.3	2	5.0	2.9
25:75 B:AH	11.4	7	5.2	5.2	5.0	5.2	7	5.0	2.9
50:50 B:AH	12.8	28	5.1	4.9	4.8	4.9	42	5.0	2.8
75:25 B:AH	14.7	70	4.9	4.6	4.4	4.5	55	4.9	2.9
25:75 S:AH	12.4	14	5.1	4.9	4.8	4.9	23	4.9	2.8
50:50 S:AH	14.6	48	5.0	4.6	4.6	4.6	60	4.9	2.9
75:25 S:AH	18.5	43	4.8	4.1	4.1	4.1	86	4.9	2.8

[a] See footnote a in Table 1.

[b] Shear values greater than 15.3 reflect the percentage of animals with tenderness values more than one standard deviation above the overall avg.

[c] Scored 1 = extremely dry, difficult, abundant, tough or bland through 8 = extremely juicy, easy, none, tender, or intense by a sensory panel.

[d] Scored 1 = intense through 4 = none by a sensory panel.