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Carcass merit between and among family groups of *Bos indicus* crossbred steers and heifers

D.A. King, W.W. Morgan, R.K. Miller, J.O. Sanders, D.K. Lunt, J.F. Taylor, C.A. Gill, J.W. Savell *

Department of Animal Science, Texas Agricultural Experiment Station, Meat Science Section, 2471 TAMU, Texas A&M University, College Station, TX 77843-2471, USA

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Abstract

Differences in live and carcass traits attributable to increasing *Bos indicus* breed influence were compared to the differences between families with similar proportions of *B. indicus* influence. Families of offspring from 1/2 Angus × 1/2 *B. indicus* mated to Angus, *B. indicus*, and 1/2 Angus × 1/2 *B.indicus* were raised under similar conditions. Average daily gain, slaughter weight, and dressing percentage were measured in addition to USDA yield and quality grade factors. Breed type did not affect average daily gain, slaughter weight, dressing percentage, carcass weight, adjusted 12th-rib fat thickness, estimated percentage kidney, pelvic, and heart fat, or carcass maturity. Predominately (3/4) Angus progeny produced greater ($P < 0.05$) longissimus muscle areas than 3/4 *B. indicus* animals. Predominately Angus cattle also had greater ($P < 0.05$) marbling scores and USDA quality grades than predominately *B. indicus* cattle. Families within breed types differed ($P < 0.05$) with regard to all traits measured. This is interesting in light of the lack of differences between breeds for most traits. In some instances, the differences in marbling score and longissimus muscle area between families within a given breed type were similar or greater in magnitude than the differences observed between predominately Angus and predominately *B. indicus* breed types. Whereas growth and carcass traits varied between levels of *B. indicus* breeding, the opportunity does exists to improve these traits by selecting within specific family lines.

Keywords: Beef; *Bos indicus*; Carcass; Cutability

1. Introduction

Cattle with *Bos indicus* influence are often discriminated against due to negative perceptions of their carcass merit and palatability compared to *Bos taurus* cattle. Many investigators have reported that *B. indicus* cattle typically produce carcasses that are lower quality and lower yielding than cattle of *B. taurus* genetics (Koch, Dikeman, & Crouse, 1982; Wheeler, Cundiff, Koch, & Crouse, 1996). Despite these reported shortcomings, *B. indicus* cattle, especially the Brahman breed, are used extensively in the southern United States. The cow productivity, heat tolerance, and insect resistance exhibited by these breeds have made them a valuable part of beef production in this region.

Heritability estimates of carcass and palatability traits indicate that much improvement could be made through selection within the current population of *B. indicus* cattle (Riley et al., 2002; Shackelford et al., 1994). Our objective was to characterize the differences in carcass traits between breed groups of predominantly Angus, predominately *B. indicus*, and half blood Angus × *B. indicus* cross cattle due to breed type, and differences due to family group within each breed type.

* Corresponding author. Tel.: +1 979 845 3935; fax: +1 979 845 9454. *E-mail address:* j-savell@tamu.edu (J.W. Savell).

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2. Materials and methods

2.1. Animal selection and handling

All calves were of known genetics from families of various combinations of Angus and *B. indicus* influence and were produced as described by Kim, Farnir, Savell, and Taylor (2003). Briefly, five combinations of Angus and *B. indicus* breed influence were evaluated. Two groups of 3/4 Angus × 1/4 *B. indicus* cattle were produced by mating Angus sires to 1/2 Angus, 1/2 *B. indicus* females (A × F1) and 1/2 Angus, 1/2 *B. indicus* bulls to Angus dams (F1 × A). Similarly, two groups of 3/4 *B. indicus,* 1/4 Angus progeny were produced by using *B. indicus* bulls on 1/2 Angus, 1/2 *B. indicus* females (B × F1) and 1/2 Angus, 1/2 *B. indicus* sires on *B. indicus* dams (F1 × B). The fifth group consisted of progeny produced by using 1/2 Angus, 1/2 *B. indicus* sires on 1/2 Angus, 1/2 *B. indicus* dams (F1 × F1). Families of animals (offspring from a single sire and dam combination) were produced by embryo transfer. The recipient cows were selected from a common herd and possessed similar genetic makeup. Positive identification was maintained by ear tags that were applied within 24 h of birth. Both Brahman and Nellore genetics were used in the *B. indicus* breed type.

All calves were raised under similar conditions at the Texas Agricultural Experiment Station in Angleton until being placed on feed. When they reached approximately seven months of age, the calves were weaned and backgrounded on pasture for 90 d. Processing at weaning included a seven-way vaccination and deworming with Ivermectin-F. Following the backgrounding period, the calves were rewormed and placed on a corn-based finishing diet at the Texas Agricultural Experiment Station at McGregor for approximately 150 d. However, days on feed varied to accommodate slaughter and data collection. Average daily gain during the feeding period was calculated for each animal. The cattle were transported 175 km to the Rosenthal Meat Science and Technology Center on the Texas A&M University campus to be harvested.

2.2. Processing and data collection procedures

All animals were harvested by conventional procedures as outlined by Savell and Smith (2000). No electrical stimulation was used. Live weights and hot carcass weights were recorded. At 48 h postmortem, the right side of each carcass was ribbed to facilitate the collection of USDA (1997) yield and quality grade data. These data included: adjusted 12th-rib fat thickness; longissimus muscle area; kidney, pelvic, and heart fat; overall maturity; and marbling score.

2.3. Statistical analysis

A total of 528 animals were included in this study. The Proc GLM procedure of SAS (SAS Institute, Cary, NC) was used to test the main effects of family (breed type), breed type, sex, and breed type × sex. The breed type × sex interaction was determined to not be a source of variation for any trait measured, and was subsequently removed from the model. Slaughter group was included in the model as a blocking factor. When appropriate, covariates including days on feed, slaughter order, days on feed within breed type, and age, were used in the model. Least-squares means were generated for all main effects not included in higher order interactions. When appropriate, LS means were separated using the PDIFF option. A predetermined probability of Type I error (α) of 0.05 was used for all judgments of statistical significance.

3. Results

3.1. Breed type effect

The effects of breed type on live animal, carcass cutability, and quality traits are presented in Table 1. Two live animal traits were evaluated in this study: average daily gain, and slaughter weight. Neither average daily gain nor slaughter weight was influenced by breed type. Similarly, dressing percentage also did not differ between breed types.

Cutability-indicating traits measured in this study were hot carcass weight; adjusted fat thickness; longissimus muscle area; percentage kidney, pelvic, and heart fat; and USDA yield grade. Carcass weight and adjusted fat thickness did not differ across breed types (Table 1). Breed type effects were observed for longissimus muscle area. Calves with predominately Angus genetics had larger ($P < 0.05$) longissimus muscle areas than those that were predominately *B. indicus*. The F1 × F1 progeny had longissimus muscle areas that were intermediate to those with greater proportions of either Angus or *B. indicus* influence. Estimated percentage of kidney, pelvic, and heart fat did not differ across the five breed types. Breed type tended ($P = 0.11$) to affect USDA yield grades. Across breed types, the F1 × F1 and F1 × B progeny had numerically lower yield grades than the other breed types.

Breed type was a source of variation for both marbling scores and USDA quality grades. Progeny that were predominately Angus received higher marbling scores than those that were predominately *B. indicus*. The F1 × F1 progeny were intermediate in their marbling scores. USDA quality grades followed the same pattern. The mean quality grade values for the predominately Angus progeny were equivalent to the lower one-third of the USDA Choice grade, while those of the predominately *B. indicus* and 1/2 Angus 1/2 *B. indicus* progeny had mean quality grade values equivalent to the USDA Select grade.

3.2. Family (breed type) effect

The least-squares means for average daily gain, slaughter weight, and dressing percentage for family (breed type)

Table 1
Least-squares means for breed type effects on live and carcass traits

Trait	Breed type[a]					RMSE[b]	$P > F$
	A × F1	F1 × A	B × F1	F1 × B	F1 × F1		
n	131	130	134	101	32	–	–
ADG[c] (kg/d)	1.20	1.30	1.12	1.01	1.18	0.21	0.88
Slaughter wt (kg)	493.7	510.4	486.3	463.8	482.0	45.5	0.51
Dressing percentage (%)	64.1	64.3	64.6	63.7	64.1	1.66	0.66
HCW[d] (kg)	317.9	328.1	314.4	296.4	308.9	31.7	0.50
AFT[e] (mm)	13.43	13.98	12.62	11.14	12.65	3.8	0.34
LMA[f] (cm^2)	77.90a	80.11a	71.79b	71.92b	77.21ab	7.68	<0.01
KPH[g] (%)	2.37	2.49	2.25	2.13	2.63	0.50	0.25
Yield grade	3.09	3.19	3.24	2.87	2.79	0.62	0.11
Overall maturity[h]	150.3	146.7	149.1	147.0	146.3	14.0	0.76
Marbling score[i]	466.1a	444.9a	365.7b	366.9b	412.9ab	70.4	0.002
Quality grade[j]	716.6a	706.9a	656.4b	654.6b	693.7ab	38.6	<0.001

Least squares means within a row lacking common letters (a,b) differ ($P < 0.05$).
[a] Breed types: A × F1 = Angus sire × 1/2 Angus, 1/2 *Bos indicus* dam; F1 × A = 1/2 Angus, 1/2 *Bos indicus* × Angus dam; B × F1 = *B. indicus* sire × 1/2 Angus, 1/2 *B. indicus* dam; F1 × B = 1/2 Angus, 1/2 *B. indicus* × *B. indicus* dam; F1 × F1 = 1/2 Angus, 1/2 *B. indicus* sire × 1/2 Angus, 1/2 *B. indicus* dam.
[b] RMSE, root mean square error from analysis of variance table.
[c] ADG, average daily gain; during feeding period.
[d] HCW, hot carcass weight.
[e] AFT, adjusted fat thickness; fat thickness at the 12th rib adjusted to reflect overall fatness of the carcass.
[f] LMA, longissimus muscle area; measured at the 12th rib.
[g] KPH, kidney, pelvic, and heart fat; estimated as a percentage of hot carcass weight.
[h] 100 = A^{00}; 200 = B^{00}.
[i] 100 = Practically devoid^{00}; 900 = Abundant^{00}.
[j] 100 = Canner^{00}; 800 = Prime^{00}.

are presented in Table 2. Differences between families within each breed type were observed for all three traits, even though no differences were observed for these traits across breed types. Average daily gain differed ($P < 0.05$) between families of all breed types except the F1 × F1 breed type. This was also the case for dressing percentage.

Family (breed type) effects for hot carcass weight; adjusted fat thickness; longissimus muscle area; percentage kidney, pelvic, and heart fat; and USDA yield grade are presented in Table 3. Hot carcass weight differed ($P < 0.05$) between families within breed type (Table 4). As would be expected, these trends were similar to those seen for slaughter weight. Adjusted fat thickness was affected by family (breed type). Families within each breed type were extremely variable in the amount of subcutaneous fat. Similarly, variation in longissimus muscle area can be seen between families within breed types. In some cases, the differences in longissimus muscle area observed between families within the same breed type are larger than the largest difference between breed types. Families within breed types differed in the percentage of kidney, pelvic, and heart fat they possessed. Even though they were statistically different, these very small differences likely have little practical meaning. USDA yield grade can be used to evaluate the overall cutability of a carcass. There was at least 1/2 of a yield grade difference in the least-squares means between families within each breed type, suggesting a considerable variation in the cutability of carcasses with the same proportion of *B. indicus* influence.

Least-squares means for overall maturity, marbling score, and USDA quality grade for family (breed type) are presented in Table 4. Families within breed type differed with regard to overall maturity. The range in overall maturity was from $A^{20}$to C^{00}. However, the least-squares means for all families were within the A maturity (youngest) classification and no meaningful differences were apparent. Marbling score and USDA quality grade also were affected by family (breed type). The range in marbling scores in the A × F1 and F1 × B breed types was 116 and 123 units, respectively, suggesting potential for improvement exists within both breed types.

3.3. Sex effect

The least-squares means for the sex effects on live animal and carcass cutability and quality traits are presented in Table 5. Heifers had slightly greater ($P < 0.05$) average daily gains than did steers. Additionally, we observed that steers had heavier ($P < 0.05$) slaughter and carcass weights as compared to heifers. Heifers were fatter than steers, exhibiting greater ($P < 0.05$) adjusted fat thicknesses and percentage kidney, pelvic, and heart fat. A sex effect also was observed for yield grade with heifers having higher ($P < 0.05$) yield grades than did steers. No differences were observed for dressing percentage, or longissimus muscle area, heifer carcasses received slightly higher ($P < 0.05$) marbling scores and tended ($P = 0.11$) to have higher quality grades than steer carcasses.

Table 2
Least-squares means for the family (breed type) effect of the live animal traits

Breed type[a]	FAM	N	ADG[b] (kg/d)	Slaughter weight (kg)	Dressing percentage
A × F1	9	23	1.24bc	502.4b	63.46c
	11	11	1.38b	519.5b	64.02bc
	13	17	1.17c	495.8b	65.86a
	15	19	0.88e	445.9c	63.21c
	17	15	0.98de	456.7c	64.19bc
	19	23	1.55a	567.4a	63.42c
	21	14	1.24bc	484.9bc	65.14ab
	23	7	1.15cd	476.3bc	63.35c
F1 × A	1	23	1.42a	549.2a	63.00d
	2	22	1.29ab	507.4c	64.45bc
	5	15	1.32a	520.6ab	65.19ab
	6	15	1.28ab	509.7bc	65.67a
	7	32	1.18b	492.3c	63.69cd
	8	25	1.32ab	483.0c	63.69cd
B × F1	10	17	1.27a	522.2a	64.76b
	12	17	1.06bc	479.8c	64.75b
	14	22	1.25a	517.0ab	64.75b
	16	22	0.95c	465.9c	63.89bc
	18	21	1.08bc	457.4c	64.79b
	20	18	1.07bc	485.1bc	62.85c
	22	17	1.16ab	479.2c	66.07a
F1 × B	25	17	1.09ab	477.2ab	63.54bcd
	26	15	0.99bc	445.0b	64.36abc
	28	10	1.06abc	463.4ab	64.97a
	29	23	1.06abc	467.2ab	62.56cd
	30	18	1.15a	477.8a	64.68ab
	31	12	0.85c	445.5ab	62.85d
	32	5	0.86c	470.6ab	63.21bcd
F1 × F1	34	14	1.15a	515.2a	64.74a
	36	18	1.20a	448.7b	63.40a
RMSE[c]		–	0.21	45.56	1.66
$P > F$		–	<0.001	<0.001	<0.001

Least-squares means within a column, within a breed type, and lacking common letters (a–c) differ ($P < 0.05$).
[a] Breed types: A × F1 = Angus sire × 1/2 Angus, 1/2 *B. indicus* dam; F1 × A = 1/2 Angus, 1/2 *B. indicus* × Angus dam; B × F1 = *B. indicus* sire × 1/2 Angus, 1/2 *B. indicus* dam; F1 × B = 1/2 Angus, 1/2 *B. indicus* × *B. indicus* dam; F1 × F1 = 1/2 Angus, 1/2 *B. indicus* sire × 1/2 Angus, 1/2 *B. indicus* dam.
[b] Average daily gain during the feeding period.
[c] RMSE, root mean square error from analysis of variance table.

4. Discussion

Clearly, animals with a greater percentage of *B. indicus* genetics would be expected to have greater expression of *B. indicus* traits. Sherbeck, Tatum, Field, Morgan, and Smith (1996) reported that live evaluators were able to segment cattle that were 1/4 Brahman, 3/4 Hereford or 1/2 Brahman, 1/2 Hereford with some success, but wide ranges of Brahman breeding were assigned, indicating that calves of the same percentage Brahman influence had different phenotypic expression of Brahman characteristics. This variation in phenotypic expression of visual breed character for animals with similar proportion of Brahman genetics suggests that these cattle may also display similar variation in carcass and meat quality traits.

4.1. Slaughter weight and dressing percent

Average daily gain did not differ across breed type in this study. However, differences were observed between families in the same breed type. In contrast, Sherbeck, Tatum, Field, Morgan, and Smith (1995) reported decreased average daily gain with increased percentage of Brahman influence. Peacock, Koger, Palmer, Carpenter, and Olson (1982) reported that among Angus-, Brahman-, and Charolais-sired calves, Brahman calves had the lowest average daily gain. In the present study, heifers had a slight advantage for average daily gain compared to steers. However, Tanner, Frahm, Willham, and Whiteman (1970) found an advantage for steers over heifers for this trait.

We found no difference in slaughter weight due to differences in Angus and *B. indicus* influence. In contrast, Koch et al. (1982) noted that the Brahman cross cattle had the heaviest final live weights compared to six other breed combinations. The present study also found heavier ($P < 0.05$) slaughter weights for steers as compared to heifers (Table 5). This is consistent to the findings of Tanner et al. (1970) who reported that at a common age, steers were heavier than heifers.

4.2. Cutability traits

As would be expected, trends in carcass weight are similar to those seen for slaughter weight. The range in observed carcass weights (197–458 kg; data not shown) is somewhat smaller than the range found in the 2000 National Beef Quality Audit (McKenna et al., 2002). Additionally, those authors reported that the mean weight for carcasses exhibiting *B. indicus* characteristics to be heavier than the means found in the present study. Sherbeck et al. (1995) found heavier carcass weights for 1/2 Brahman 1/2 Hereford calves when compared to 3/4 Hereford 1/4 Brahman and full-blood Hereford calves. Crouse, Cundiff, Koch, Koohmaraie, and Seideman (1989) reported carcass weights to be heavier in 1/4 Brahman calves compared to 1/2 and 3/4 Brahman carcasses. However, in that study, the 1/2 Brahman carcasses had the lowest carcass weights.

We observed steers to have heavier carcass weights than heifers, which agrees with Tanner et al. (1970) who found carcasses from steers to be heavier than those from heifers when fed to similar endpoints. McKenna et al. (2002) also reported steer carcasses to be heavier than heifer carcasses.

In our study, predominately Angus cattle had greater longissimus muscle areas than predominately *B. indicus* cattle. Lunt, Smith, Murphey, Savell, and Carpenter (1985) did not observe differences in longissimus muscle area in Angus, Brahman, and 1/2 Angus, 1/2 Brahman calves fed for different periods of time. Sherbeck et al. (1995) found Hereford calves to have smaller longissimus muscle areas than 1/4 and 1/2 Brahman calves. The

Table 3
Least-squares means for the family (breed type) effect of the cutability traits

Breed type[a]	FAM	HCW[b] (kg)	Adjusted fat thickness[c] (mm)	LMA[d] (cm^2)	KPH (%)	Yield grade
A × F1	9	328.0b	10.67c	85.14a	2.21bc	2.52c
	11	331.7b	12.83bc	80.37abc	2.58ab	3.11b
	13	326.9b	12.75bc	80.30abc	2.60a	2.99b
	15	282.3d	14.10b	71.79d	1.95c	3.04b
	17	294.1cd	14.68ab	78.30bc	2.58ab	3.04b
	19	358.8a	13.21b	82.50ab	2.30abc	3.20b
	21	317.1bc	17.81a	69.85d	2.57ab	3.85a
	23	304.2bcd	11.35bc	74.82cd	2.20bc	2.95bc
F1 × A	1	352.4a	13.25bc	85.77a	2.53ab	3.06bc
	2	325.9bc	16.09a	85.14a	2.51ab	3.13abc
	5	337.3ab	15.21ab	81.01ab	2.40b	3.39ab
	6	329.2abc	15.63ab	77.92b	2.79a	3.54a
	7	315.0cc	17.01c	77.85b	2.24b	2.90c
	8	309.0c	11.73c	77.82c	2.44ab	3.11abc
B × F1	10	341.7a	12.06b	78.17a	2.52a	3.01c
	12	310.1c	9.68c	65.73d	2.01b	3.24bc
	14	333.2ab	15.21a	74.95ab	2.24ab	3.50ab
	16	298.1c	12.67ab	72.24bc	2.04b	2.94c
	18	297.8c	14.56ab	74.11ab	2.42a	3.21bc
	20	304.3c	9.96c	68.89cd	2.04b	3.02c
	22	315.6bc	14.33ab	68.24cd	2.50a	3.74a
F1 × B	25	306.1ab	10.62bc	74.54a	1.89a	2.70ab
	26	287.4bc	13.11ab	71.47a	1.94a	2.94ab
	28	302.5abc	12.30abc	71.66a	2.33a	2.88ab
	29	289.0bc	9.85c	72.05a	2.04a	2.59b
	30	310.4a	13.36a	75.01a	2.28a	3.12a
	31	280.8c	9.62c	70.24a	2.17a	2.75ab
	32	298.4abc	9.17c	68.18a	2.27a	3.09ab
F1 × F1	34	319.9a	12.66a	82.55a	2.76a	2.88a
	36	298.0a	12.65a	71.72b	2.50a	2.71a
RMSE[e]		31.65	3.77	7.68	0.50	0.62
$P > F$		<0.001	<0.001	<0.001	<0.001	<0.0011

Least-squares means within a column, within a breed type, and lacking common letters (a–d) differ ($P < 0.05$).
[a] Breed types: A × F1 = Angus sire × 1/2 Angus, 1/2 *B. indicus* dam; F1 × A = 1/2 Angus, 1/2 *B. indicus* × Angus dam; B × F1 = *B. indicus* sire × 1/2 Angus, 1/2 *B. indicus* dam; F1 × B = 1/2 Angus, 1/2 *B. indicus* × *B. indicus* dam; F1 × F1 = 1/2 Angus, 1/2 *B. indicus* sire × 1/2 Angus, 1/2 *B. indicus* dam.
[b] Hot carcass weight.
[c] Measured at the 12th rib and adjusted to reflect the overall fatness of the carcass.
[d] LMA, longissimus muscle area measured at the 12th–13th rib interface.
[e] RMSE, root mean square error from analysis of variance table.

range in longissimus muscle areas in this study (47.7–109.7 cm^2; data not shown) was smaller than the range of 50.3–149.7 cm^2 reported by McKenna et al. (2002). Additionally, the mean longissimus muscle areas for the different breed types evaluated in this study were slightly smaller than those reported by McKenna et al. (2002) for the overall population and the *B. indicus* influenced carcasses.

In contrast to our results, Lunt et al. (1985) found differences in kidney, pelvic, and heart fat for calves with differing Angus and Brahman influence, but no pattern was discernable in those differences and the differences changed during the different feeding times of their trial. Sherbeck et al. (1995) did not find differences in kidney, pelvic, and heart fat between Hereford and two levels of Brahman influenced calves. Additionally, steers exhibited less kidney pelvic, and heart fat than heifers (Table 5). In contrast, neither McKenna et al. (2002) nor Tanner et al. (1970) found a difference in kidney, pelvic, and heart fat due to sex.

No differences in adjusted fat thickness were observed between breed types in this study. In agreement with our findings, Lunt et al. (1985) found very little difference between different breed type combinations. Similarly, Sherbeck et al. (1995) saw no difference in fat thickness for breed combinations in their study. Peacock et al. (1982) did not report any difference in fat opposite the longissimus muscle between calves of differing percentage Brahman and Angus influence.

Although no differences were observed in fat thickness between breed types in the present study, families within each breed type exhibited large differences in the amount of subcutaneous fat. Additionally, steers had considerably less external fat than heifers. The finding that steers had less fat than heifers is supported by the results of McKenna

Table 4
Least-squares means for the family (breed type) effect on carcass quality traits

Breed type[a]	FAM	Overall maturity[b]	Marbling score[c]	Quality grade[d]
A × F1	9	148.6b	389.8e	678.1d
	11	153.8b	547.1a	752.6a
	13	150.3b	428.2cde	707.1bc
	15	156.3b	450.6bc	707.1bc
	17	155.0b	401.7de	690.4c
	19	167.7a	560.9a	752.2a
	21	146.2b	444.3bcd	708.5bc
	23	154.9b	506.1ab	737.1ab
F1 × A	1	153.8a	463.4b	719.8ab
	2	150.2a	513.7a	739.0a
	5	154.1a	451.7bc	712.0bc
	6	158.7a	411.1c	690.0cd
	7	150.8a	413.8c	694.0cd
	8	150.3a	415.6c	686.4d
B × F1	10	153.8a	386.6ab	677.0a
	12	148.6a	350.0bc	644.2bc
	14	149.9a	395.9a	683.1a
	16	152.2a	329.7bc	620.0c
	18	150.2a	364.0abc	661.9ab
	20	153.4a	343.9bc	633.0c
	22	158.8a	390.2ab	676.6a
F1 × B	25	149.9ab	422.1a	684.0ab
	26	151.7ab	441.3a	705.9a
	28	160.0a	361.1b	647.5c
	29	142.7b	327.5b	628.2c
	30	154.0a	318.3b	620.5c
	31	150.3ab	338.2b	639.7c
	32	150.6ab	359.8b	656.1bc
F1 × F1	34	158.9a	403.5a	695.8a
	36	159.6a	422.3a	691.5a
RMSE[e]		13.98	70.41	38.81
$P > F$		<0.01	<0.001	<0.001

Least-squares means within a column, within a breed type, and lacking common letters (a–e) differ ($P < 0.05$).
[a] Breed types: A × F1 = Angus sire × 1/2 Angus, 1/2 *B. indicus* dam; F1 × A = 1/2 Angus, 1/2 *B. indicus* × Angus dam; B × F1 = *B. indicus* sire × 1/2 Angus, 1/2 *B. indicus* dam; F1 × B = 1/2 Angus, 1/2 *B. indicus* × *B. indicus* dam; F1 × F1 = 1/2 Angus, 1/2 *B. indicus* sire × 1/2 Angus, 1/2 *B. indicus* dam.
[b] 100 = A^{00}; 200 = B^{00}.
[c] 100 = Practically devoid^{00}; 900 = Abundant^{00}.
[d] 100 = Canner^{00}; 800 = Prime^{00}.
[e] RMSE, root mean square error from analysis of variance table.

Table 5
Least-squares means for sex effects on live and carcass traits

Trait	Sex		RMSE[a]	$P > F$
	Steer	Heifer		
N	271	257	–	–
ADG[b] (kg/d)	1.14b	1.18a	0.21	0.03
Slaughter wt (kg)	498.64b	475.8a	45.56	<0.001
Dressing percentage	64.06	64.23	1.66	0.27
HCW[c] (kg)	320.9a	305.3b	31.65	<0.001
AFT[d] (mm)	10.81b	14.72a	3.77	<0.001
LMA[e] (cm^2)	76.34	75.21	0.68	0.11
KPH[f] (%)	2.25b	2.50a	0.50	<0.001
Yield grade	2.86b	3.21a	0.62	<0.001
Overall maturity[g]	147.4b	160.6a	13.98	<0.001
Marbling score[h]	403.7b	418.9a	70.4	0.04
Quality grade[i]	682.8	688.5	38.81	0.11

LS means within a row and lacking common letters (a,b) differ ($P < 0.05$).
[a] RMSE, root mean square error from analysis of variance table.
[b] ADG, average daily gain during feeding period.
[c] HCW, hot carcass weight.
[d] AFT, adjusted fat thickness; measured at the 12th rib adjusted to reflect overall fatness of he carcass.
[e] LMA, longissimus muscle area: measured at the 12th rib.
[f] KPH: kidney, pelvic, and heart fat; estimated as a percentage of hot carcass weight.
[g] 100 = A^{00}; 200 = B^{00}.
[h] 100 = Practically devoid^{00}; 900 = Abundant^{00}.
[i] 100 = Canner^{00}; 800 = Prime^{00}.

et al. (2002) who also reported steers having less fat thickness than heifers. In contrast, Tanner et al. (1970) found steers to be fatter than heifers. The range of adjusted fat thicknesses observed in the present study was from 2.5 to 30.5 mm (data not shown in tabular form). This is similar to, but smaller than the range of 0–44 mm reported by McKenna et al. (2002).

As mentioned earlier large variations existed in the USDA yield grades of families within a given breed type. However, breed type only tended ($P = 0.11$) to affect yield grade. Neither Lunt et al. (1985), nor Sherbeck et al. (1995) found breed differences on yield grade in their studies. Our findings regarding cutability indicating traits in this study suggest that the variation in retail product yields between animals within a given breed are larger than the differences between breed types.

McKenna et al. (2002) reported that heifers had lower yield grades than steers, though the difference reported by those authors is not large enough to be of practical importance. The range in yield grade (1.0–5.6; data not shown) is less variable, but within the range reported by McKenna et al. (2002).

4.3. Quality traits

Though differences in overall maturity were observed between families within breed types, no meaningful differences were apparent. All of the least-squares means were within the A maturity (youngest) classification. The range in overall maturity (A^{20} to C^{00}) was larger than expected because the animals were all of similar chronological age and background.

Marbling score and quality grade were affected by both breed type and family (breed type). The differences in marbling scores across families of the same breed type were similar in magnitude to the differences between breed types. This suggests that cattle within breed types can be selected to make changes in the marbling deposited by animals within that breed type. This is an important finding because cattle exhibiting *B. indicus* characteristics are often discriminated against due to reduced quality grades compared to *B. taurus* cattle. These data are consistent with the findings of Crouse et al. (1989), who reported decreases in marbling scores with increasing percentage of Brahman influence. Sherbeck et al. (1995) also reported an advantage in marbling scores for straight Hereford calves compared to higher percentages of Brahman influence, but found no difference between 1/2 and 1/4 Brahman calves. Lunt et al. (1985) found little difference in marbling between Angus and Brahman calves when fed for a common number of days. The ranges in marbling score and quality grade (Practically Devoid^{70} to Moderately Abundant^{80} and Standard^{35} to Prime^{60}, respectively) are consistent with the range of these traits observed for the entire beef population (McKenna et al., 2002).

5. Conclusions

In the US, cattle of predominately *B. indicus* influence are discriminated against due to a perceived deficiency in carcass merit compared to animals of *B. taurus* genetics. For the carcass traits measured, differences exist between families of the same percentage of *B. indicus* influence. In some instances, the differences between families were greater than the differences between breed types. This suggests that progress can be made by selecting individuals within the current population of *B. indicus* cattle. Consequently, the differences between breed types can be reduced, if not eliminated, through selection within the breed type.

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