Breed Differences and Heterosis Effects for Carcass and Meat Palatability Traits in an Angus-Brahman Multibreed Cattle Population

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Estimates of additive breed genetic effects indicated that Brahman carcasses had higher dressing percent, lower marbling, smaller ribeye area, and less fat over the ribeye than Angus. Brahman beef was tougher, had more connective tissue, and it was less juicy than Angus beef. Heterosis increased hot carcass weight, dressing percent, ribeye area, fat over the ribeye, and kidney, pelvic, and heart fat in Angus-Brahman crossbred steers. Results indicated that crossbred animals with percentage Brahman up to 50% showed limited negative impact on meat quality while maximizing meat yield due to heterosis.

Summary

Carcass and meat palatability characteristics constitute key factors for the success of beef cattle operations. Consumers prefer meat that has certain desirable degrees of tenderness, marbling, juiciness, and flavor. Cattle in the Southern region of the US contain some Brahman influence to help them cope with hot and humid climatic conditions. However, meat from Brahman cattle tends to be less tender than meat from Bos taurus breeds, causing branded beef products to restrict Brahman from their beef products. Information on Brahman purebred and crossbred cattle is needed for objective evaluation of carcass and meat palatability traits. This research quantified additive genetic differences between Angus and Brahman, estimated Angus-Brahman heterosis effects, and estimated least squares means for six carcass and six meat palatability traits using data from 1367 steers from the Angus-Brahman multibreed herd of the University of Florida collected from 1989 to 2009. Estimates of additive genetic breed differences between Brahman and Angus indicated that Brahman carcasses had higher dressing percent, lower marbling, smaller ribeye area, and less fat over the ribeye than Angus. In addition, Brahman beef was tougher, had more connective tissue, and it was less juicy than Angus beef. Lastly, heterosis increased hot carcass weight, dressing percent, ribeye area, fat over the ribeye, and kidney, pelvic, and heart fat in Angus-Brahman crossbred steers. Results indicated that crossbred animals with percentage Brahman up to 50% showed limited negative impact on meat quality while maximizing meat yield due to heterosis.

Introduction

Carcass and meat palatability characteristics constitute key factors for the success of beef cattle operations. Consumers prefer meat that has certain desirable degrees of tenderness, marbling, juiciness, and flavor. This has led to the establishment of over 60 branded beef products in the United States (USDA, 2010). Thus, it seems reasonable for cattle producers to breed animals that take advantage of opportunities presented by branded beef programs while simultaneously breeding animals that survive well under a variety of environmental conditions. The Southern region of the US with its hot and humid subtropical environment presents serious challenges to beef producers. Most cattle in this region contain some percentage of Brahman to help them cope with climatic conditions, particularly during the summer season. However, meat from Brahman cattle is known to be less tender than meat from *Bos taurus* breeds. This has led to restrictions on the percent of Brahman breeding by the majority of branded beef products. Information

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on Brahman cattle and its crossbreds with *Bos taurus* breeds is needed to objectively evaluate their ability for carcass and meat palatability traits relative to that of *Bos taurus* breeds. The Angus-Brahman multibreed herd of the University of Florida with cattle ranging from 100% Angus to 100% Brahman is well suited to evaluate Angus, Brahman, and crossbred groups of any Angus and Brahman fraction for each carcass and meat palatability traits under Florida environmental conditions. Thus, the objectives of this research were to obtain estimates of additive genetic differences between Angus and Brahman, Angus-Brahman heterosis effects, and to compute least squares means for breed groups of calves ranging from 100% Angus to 100% Brahman for six carcass and six meat palatability traits using the complete Angus-Brahman multibreed dataset of the University of Florida.

Materials and Methods

Animals, date, and traits

Cattle were from a long-term genetic evaluation study utilizing Angus, Brahman, and Angus-Brahman cattle from the multibreed herd of the University of Florida. The mating design used in this herd was diallel, i.e., sires of six breed groups (Angus (A), ¾ A ¼ B, Brangus (5/8 A 3/8 B), ½A ½B, ¼A ¾B, and Brahman (B)) were mated to dams from these same six breed groups. The dataset contained carcass and meat palatability information from 1,367 calves born from 1989 to 2009 (216 Angus, 182 ¾ A ¼ B, 224 Brangus, 341 ½A ½B, 206 ¼A ¾B, and 198 Brahman). These calves were the progeny of 213 sires (44 Angus, 27 ¾ A ¼ B, 42 Brangus, 26 ½A ½B, 26 ¼A ¾B, and 48 Brahman) and 824 dams (145 Angus, 119 ¾ A ¼ B, 127 Brangus, 174 ½A ½B, 107 ¼A ¾B, and 152 Brahman). Carcass traits were hot carcass weight (HCW, lb), dressing percent (DP, %), ribeye area at the 12th rib (REA, in^2), fat over the ribeye the 12th rib (FOE, in), kidney, pelvic, and heart fat (KPH, %), and marbling score (MAB; 100 to 199 = practically devoid, 900 to 999 = abundant). Meat palatability traits were Warner-Bratzler shear force (WBSF, lb), tenderness score (TEND; 1 = extremely tough, 8 = extremely tender), connective tissue score (CTI; 1 = abundant amount, 8 = none detected), juiciness score (JUIC; 1 = extremely dry, 8 = extremely juicy), beef flavor score (FLAV; 1 = extremely bland, 8 = extremely intense), and off-flavor score (OFLAV; 1 = extreme off-flavor, 6 = none detected).

Reproduction, feeding, and management

Cows were synchronized in March, artificially inseminated twice, and then exposed to a natural service bull for 60 d. Calves were born from mid-December to mid-March, and weaned in September. Cows and calves were kept on bahiagrass (*Paspalum notatum)* pastures throughout the year with free access to mineral supplementation. Winter supplementation consisted of bermudagrass *(Cynodon dactylon)* hay, cottonseed meal, and molasses. After weaning steers were either taken directly to a contract feeder (1989 to 2005; King Ranch Feedyard, Kingsville, Texas), or to the University of Florida Feed Efficiency Facility (FEF) in Marianna, Florida for 100 d, and then transported to a contract feeder (2006 to 2009; Suwannee Farms, O'Brien, Florida). Steers at the FEF were housed in pens and fed a concentrate diet composed of whole corn, cottonseed hulls, and a protein, vitamin, and mineral supplement (FRM, Bainbridge, GA). The FEF concentrate had 90 to 91.2% of dry matter, 14.1 to 17. 3 % of crude protein, 1.5 to 1.7 Mcal/kg DM of Net Energy maintenance, and 0.9 to 1.2 Mcal/kg DM of Net Energy gain. Steers were provided a standard commercial corn-protein diet with vitamins and minerals at the feedlot until they reached a subcutaneous fat thickness of approximately 0.5 in.

Carcass and meat palatability evaluation

At the end of the feeding period, cattle were transported to a commercial packing plant (Sam Kane Beef Processors, Corpus Christi, TX), and harvested in a conventional manner under USDA, FSIS inspection. After 24 h postmortem, carcasses were ribbed and data collected including HCW, DP, REA, FOE, KPH, and MAB (USDA, 1997). After carcass evaluation, carcasses were fabricated and a wholesale rib was removed and transported to the Meat Processing Center, University of Florida. Two 1-in steaks were removed from the 12th rib end of the wholesale rib, one for

Warner-Bratzler shear force determination and one for sensory panel evaluation. Steaks were frozen at 14 d post-mortem and remained frozen until subsequent shear force and sensory evaluation. A 7 to 11 member trained (AMSA, 1995) panel evaluated each sample for five sensory attributes (TEND, CTI, JUIC, FLAV, OFLAV).

Statistical analysis

Carcass traits (HCW, DP, REA, FOE, KPH, and MAB) and meat palatability traits (WBSF, TEND, CTI, JUIC, FLAV, and OFLAV) were analyzed using single-trait mixed model procedures that accounted for additive genetic, non-additive genetic, and environmental effects, and assumed a homogeneous residual covariance structure. The model used for all traits contained the fixed effects of year of birth, the fixed regression effects of slaughter age of steer, Brahman breed effect (as a function of the Brahman fraction of the steer), and heterosis effect (as a function of the heterozygosis of the steer), and a random residual effect. Random residual effects were assumed to have zero mean, a common variance, and uncorrelated. Brahman breed effects estimated the additive genetic difference between Brahman and Angus. Heterosis effects estimated the difference between interbreed interactions (i.e., Angus-Brahman and Brahman-Angus) and intrabreed interactions (i.e., Angus-Angus and Brahman-Brahman) at 1 locus. The procedure MIXED of SAS (SAS Inst., Inc., Cary, NC) was used for mixed model computations. The statistical significance of solutions for effects in the model was assessed with a t-test. Least squares means were computed for all breed groups of steers (Angus, ¾ A ¼ B, Brangus, ½A ½B, ¼A ¾B, and Brahman) using a linear combination of additive genetic breed effects and non-additive genetic heterosis effects. Figures depicting trends for carcass and meat palatability traits across breed groups of steers.

Results

Carcass traits

Table 1 presents estimates of additive genetic Brahman minus Angus differences and non-additive Angus-Brahman heterosis effects for HCW, DP, REA, FOE, KPH, and MAB. Additive breed differences indicate that Brahman carcasses had significantly ($P < 0.0001$) higher DP, lower MAB, smaller REA, and less FOE, but similar HCW and KPHF. In contrast, heterosis effects increased HCW ($P < 0.0001$), DP ($P < 0.017$), REA ($P < 0.0001$), FOE ($P < 0.0001$), and KPHF ($P < 0.01$), but it did not affect MAB. The large effect of heterosis on HCW (77.03 ± 8.69, $P < 0.0001$) overshadows the negative impact of the additive difference between Brahman and Angus (-105.97 ± 7.68, $P < 0.0001$) for crossbred animals under current market conditions. Table 3 shows least squares means and their standard errors computed for six breed groups of steers (Angus, ¾ A ¼ B, Brangus, ½A ½B, ¼A ¾B, and Brahman). Trends resulting from these steer group means are shown in Figure 1. Crossbred steers tended to have heavier HCW than Angus and Brahman steers due primarily to heterosis effects, thus the heaviest carcasses were those from F1 steers. A similar pattern existed for KPH. Dressing percent tended to increase linearly from Angus to ½A ½B, and to remain at this level in steers with higher Brahman percentages. Marbling score decreased steadily from Angus to Brahman. Ribeye area tended to increase slightly from Angus to ½A ½B, and then to decrease towards Brahman. A similar trend existed for FOE.

Meat palatability traits

Table 2 shows estimates of additive genetic differences between Brahman and Angus as well as Angus-Brahman heterosis effects for WBSF, TEND, CTI, JUIC, FLAV, and OFLAV. Additive genetic breed differences suggest that Brahman steaks were significantly ($P < 0.0001$) tougher based on WBSF and sensory panel TEND, and sensory panel members perceived them to have higher levels of CTI ($P < 0.0001$) and to have lower levels of JUIC ($P < 0.001$). However, no differences between Brahman and Angus were detected for FLAV and OFLAV. Heterosis effects had no impact on any meat palatability traits. Table 4 contains least squares means for the six breed groups of steers (Angus, ¾ A ¼ B, Brangus, ½A ½B, ¼A ¾B, and Brahman), and Figure 2 shows trends for the six meat palatability traits in this study. Means for WBSF showed a clear upward trend from Angus to Brahman, whereas the opposite trend was observed for sensory panel tenderness. The decreasing trend for CTI was similar to the one found for tenderness. Juiciness showed a steady decline from Angus to Brahman. As expected from the non-significant additive genetic breed and non-additive genetic heterosis effects, means for FLAV and OFLAV showed no trend from Angus to Brahman.

Table 1. Additive genetic breed differences and heterosis effects for six carcass traits

Trait	n	Effect	Estimate	Standard Error	Pr > |t|
HCW, lb	1,359	Brahman - Angus	5.84	7.56	0.44
		Heterosis	77.03	8.69	<0.0001
DP, %	1,359	Brahman - Angus	1.60	0.25	<0.0001
		Heterosis	0.69	0.29	0.017
MAB, score[a]	1,357	Brahman - Angus	-105.97	7.68	<0.0001
		Heterosis	0.26	8.83	0.98
REA, in^2	1,328	Brahman - Angus	-0.59	0.14	<0.0001
		Heterosis	0.82	0.17	<0.0001
FOE, in	1,353	Brahman - Angus	-0.15	0.02	<0.0001
		Heterosis	0.10	0.02	<0.0001
KPHF, %	1,275	Brahman - Angus	-0.08	0.05	0.15
		Heterosis	0.16	0.06	0.01

[a] 100 to 199 = practically devoid, 900 to 999 = abundant.

Table 2. Additive genetic breed differences and heterosis effects for six meat palatability traits

Trait	n	Effect	Estimate	Standard Error	Pr > |t|
WBSF, lb	662	Brahman - Angus	1.54	0.25	<0.0001
		Heterosis	-0.12	0.30	0.68
TEND, score[a]	352	Brahman - Angus	-1.18	0.15	<0.0001
		Heterosis	0.26	0.17	0.13
CTI, score[b]	352	Brahman - Angus	-0.97	0.14	<0.0001
		Heterosis	0.29	0.16	0.062
JUIC, score[c]	352	Brahman - Angus	-0.40	0.12	0.001
		Heterosis	-0.09	0.14	0.54
FLAV, score[d]	352	Brahman - Angus	0.05	0.09	0.56
		Heterosis	0.18	0.10	0.08
OFLAV, score[e]	352	Brahman - Angus	-0.04	0.07	0.57
		Heterosis	-0.10	0.08	0.22

[a] 1 = extremely tough, 8 = extremely tender.

[b] 1 = abundant amount, 8 = none detected.

[c] 1 = extremely dry, 8 = extremely juicy.

[d] 1 = extremely bland, 8 = extremely intense.

[e] 1 = extreme off-flavor, 6 = none detected.

Table 3. Steer breed group least squares means for six carcass traits

	Breed Group					
Trait	Angus	¾ A ¼ B	Brangus	½ A ½ B	¼ A ¾ B	Brahman
HCW, lb	711.22[b]	751.19[x]	749.53[x]	791.16[x]	754.11[x]	717.05
	5.78[c]	2.70	2.19	5.34	2.98	5.62
DP, %	61.66	62.41[x]	62.59[x]	63.16[x]	63.21[x]	63.26[x]
	0.19	0.09	0.07	0.18	0.10	0.19
MAB, score[a]	446.51	420.15[x]	406.90[x]	393.79[x]	367.17[x]	340.55[x]
	5.87	2.74	2.22	5.43	3.03	5.72
REA, in^2	12.64	12.90[x]	12.80	13.17[x]	12.61	12.05[x]
	0.11	0.05	0.04	0.10	0.06	0.11
FOE, in	0.50	0.52	0.49	0.53	0.44[x]	0.35[x]
	0.01	0.01	0.01	0.01	0.01	0.01
KPH, %	2.14	2.20	2.19	2.26	2.16	2.06
	0.04	0.02	0.02	0.04	0.02	0.04

[a] 100 to 199 = practically devoid, 900 to 999 = abundant.

[b] Least squares mean

[c] Standard error

[x] Significantly different from Angus ($P < 0.0047$ to $P < 0.0001$).

Table 4. Steer breed group least squares means for six meat palatability traits

	Breed Group					
Trait	Angus	¾ A ¼ B	Brangus	½ A ½ B	¼ A ¾ B	Brahman
WBSF, lb	7.59[f]	7.91[y]	8.11[x]	8.24[y]	8.68[x]	9.13[x]
	0.19[g]	0.09	0.07	0.19	0.10	0.18
TEND, score[a]	5.80	5.64	5.48[x]	5.48	5.05[x]	4.62[x]
	0.12	0.06	0.05	0.11	0.06	0.11
CTI, score[b]	6.11	6.01	5.88[x]	5.92	5.53[x]	5.14[x]
	0.11	0.05	0.04	0.10	0.06	0.10
JUIC, score[c]	5.31	5.17	5.12[x]	5.02	4.97[x]	4.91[x]
	0.10	0.05	0.04	0.09	0.05	0.09
FLAV, score[d]	5.45	5.55	5.56	5.66	5.58	5.50
	0.07	0.03	0.03	0.06	0.04	0.07
OFLAV, score[e]	5.81	5.75	5.75	5.69	5.73	5.77
	0.06	0.03	0.02	0.05	0.03	0.05

[a] 1 = extremely tough, 8 = extremely tender.

[b] 1 = abundant amount, 8 = none detected.

[c] 1 = extremely dry, 8 = extremely juicy.

[d] 1 = extremely bland, 8 = extremely intense.

[e] 1 = extreme off-flavor, 6 = none detected.

[f] Least squares mean

[g] Standard error

[x] Significantly different from Angus ($P < 0.0244$ to $P < 0.0001$)

[y] Difference from Angus close to significance ($P < 0.0546$)

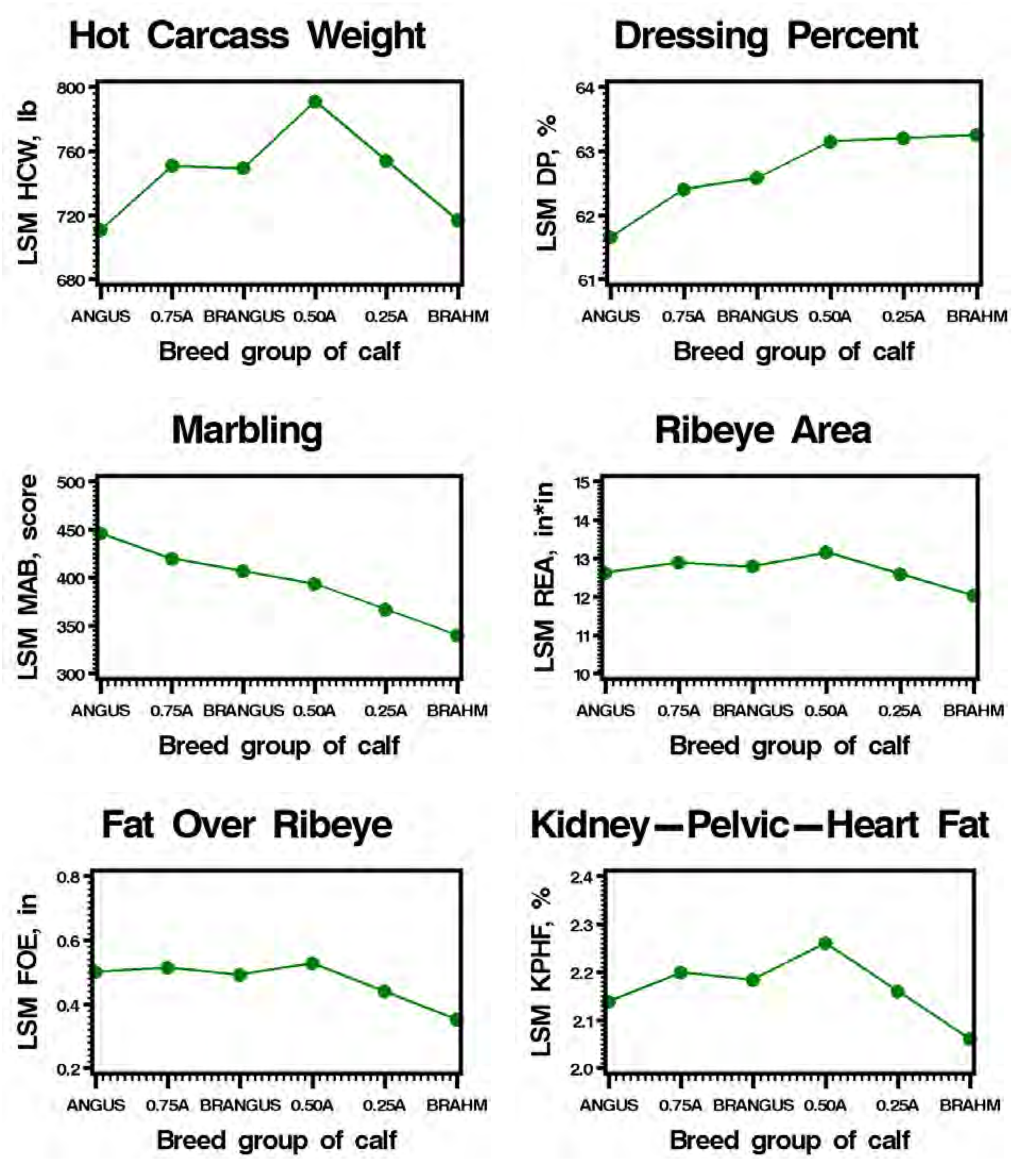

Figure 1. Trends of least squares means (LSM) for carcass traits for steers ranging in breed composition from 100% Angus to 100% Brahman

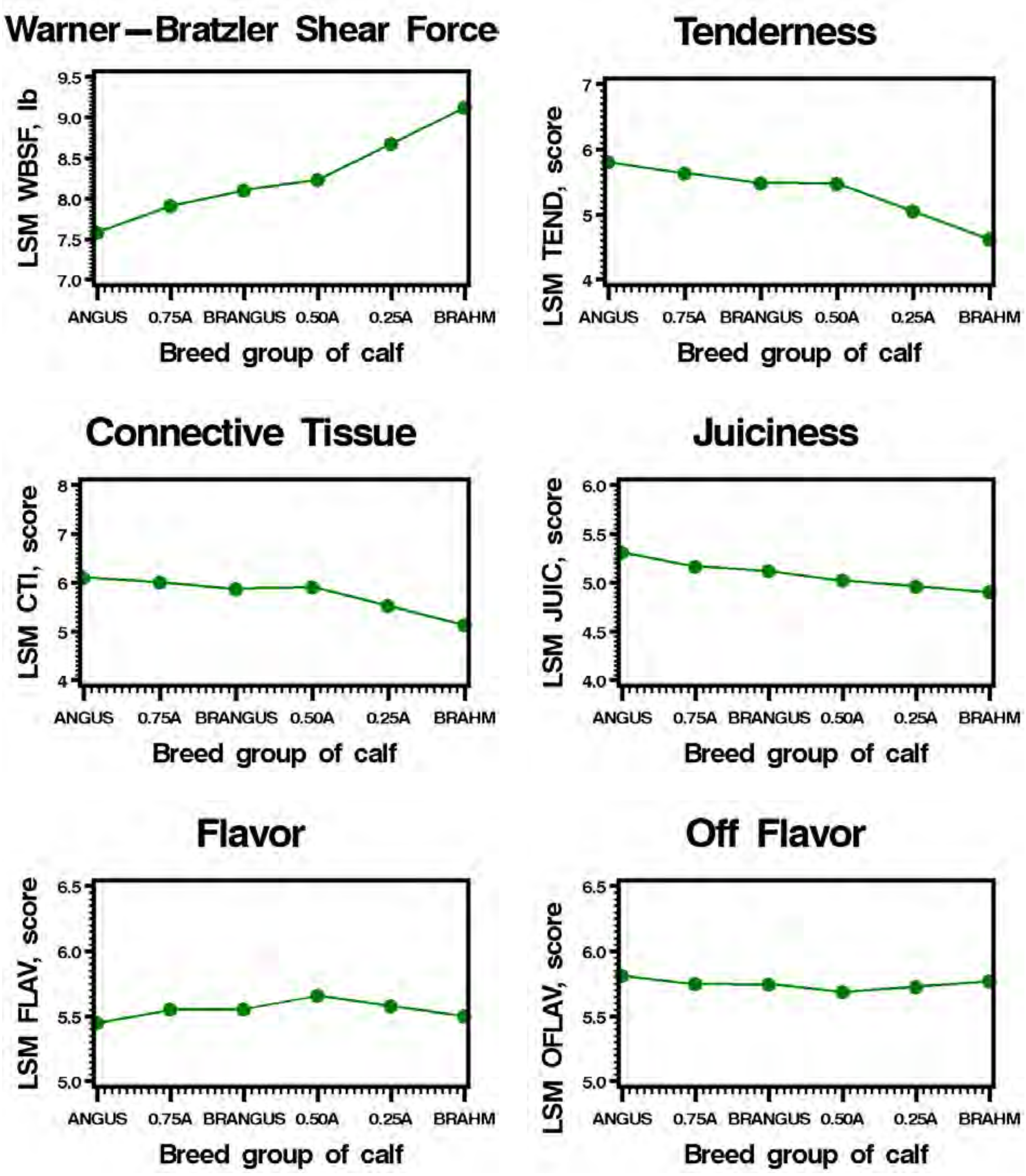

Figure 2. Trends of least squares means (LSM) for meat palatability traits for steers ranging in breed composition from 100% Angus to 100% Brahman