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Effect of Wagyu- versus Angus-sired calves on feedlot performance, carcass characteristics, and tenderness

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ABSTRACT: Wagyu-sired (n = 20) and Angus-sired (n = 19) steers and heifers were used to compare the effects of sire breed on feedlot performance, carcass characteristics, and meat tenderness. Calves were weaned at 138 ± 5 d of age and individually fed a finishing diet consisting of 65% whole corn, 20% protein/vitamin/mineral supplement, and 15% corn silage on a DM basis. Heifers and steers were slaughtered at 535 and 560 kg of BW, respectively. Carcasses were ribbed between the 12th and 13th (USDA grading system) and the 6th and 7th ribs (Japanese grading system) to measure fat thickness, LM area (LMA), and intramuscular fat (IMF). Two steaks were removed from the 12th rib location and aged for 72 h and 14 d to determine Warner-Bratzler shear force and cooking loss. Sire breed × sex interactions were not significant ($P > 0.05$). Angus-sired calves had greater ($P < 0.05$) ADG and DMI than Wagyu. Wagyu-sired calves had improved ($P < 0.05$) feed efficiency than Angus. Sire breed did not affect ($P > 0.20$) HCW, 12th-rib fat, or USDA yield grade. Carcasses of Wagyu had greater ($P = 0.0001$) marbling scores at the 12th rib than those of Angus (770.9 vs. 597.3 ± 41.01, respectively). Carcasses of Wagyu also had greater ($P < 0.02$) 12th-rib IMF and 6th-rib IMF than Angus, resulting in a greater proportion of carcasses grading Prime (65.0 vs. 21.1%; $P = 0.006$). Carcasses from Wagyu tended ($P = 0.08$) to have greater LMA at the 12th rib, whereas Angus carcasses had greater ($P < 0.05$) LMA at the 6th rib. Steaks from Angus and Wagyu had similar ($P > 0.50$) tenderness at aging times of 72 h and 14 d. Cooking loss was greater ($P < 0.01$) for Angus than Wagyu steaks at 72 h and 14 d. Using Wagyu sires vs. Angus sires on British-based commercial cows combined with early weaning management strategies has the potential to produce a product with greater marbling, but is unlikely to significantly enhance tenderness.

Key words: Angus, meat quality, Wagyu

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INTRODUCTION

Value-based and niche marketing systems in the beef cattle industry have resulted in increased emphasis on producing high quality beef. National Beef Quality Audits have consistently identified marbling as a key concern for purveyors, restaurateurs, and retailers, and marbling has been reported to be highly correlated to juiciness and beef flavor (Platter et al., 2003). A variety of studies have also indicated that tenderness is the most important factor in beef palatability or overall preference (Savell et al., 1987; Miller et al., 2001; Thompson, 2002). The current literature indicates that using Wagyu sires in a cross-breeding system can improve Warner-Bratzler shear force values (Wheeler et al., 2004) and result in greater rates of postmortem aging (Kuber et al., 2004).

Japanese Wagyu influenced cattle have demonstrated exceptional amounts of marbling (Mir et al., 1999; Wheeler et al., 2004) even when compared with Angus contemporaries (Lunt et al., 1993). However, decreased red meat yield and feedlot performance have been reported with Wagyu and Wagyu-crossbred cattle (Lunt et al., 1993; Mir et al., 1999).

Previous studies have documented that early weaned cattle introduced to a high-grain finishing diet at an early age deposit more intramuscular fat (**IMF**), resulting in a greater percentage of cattle grading USDA Choice compared with normal-weaned counterparts (Fluharty et al., 2000; Meyer et al., 2005). Wertz et al. (2002) reported that early weaning Wagyu × Angus heifers is likely to allow a greater number of calves to reach a quality grade that is associated with grid premiums, but may compromise feed efficiency.

The objective of this study was to evaluate the effects of using an early weaning management system with An-

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Table 1. Diet composition and nutrient composition

Item	Composition[1]
Ingredient, % of DM	
Whole shelled corn	65.00
Corn silage	15.00
Soybean meal	12.37
Ground corn	4.14
Limestone	1.19
Urea	0.62
Dicalcium phosphate	0.44
Trace mineral salt[2]	0.44
Dynamate[3]	0.36
Animal-vegetable fat	0.20
Potassium chloride	0.13
Se, 201 mg/kg	0.04
Vitamin E, 44 IU/g	0.03
Rumensin 80[4]	0.01
Vitamin A, 30,000 IU/g	0.01
Formulated nutrient composition[5]	
NE_m, Mcal/d	2.12
NE_g, Mcal/d	1.46
CP, % of DM	14.03
Ca, % of DM	0.59
P, % of DM	0.37

[1]Values expressed as percent of diet on a DM basis.

[2]Contained >93% NaCl, 0.35% Zn, 0.28% Mn, 0.175% Fe, 0.035% Cu, and 0.007% Co.

[3]Magnesium sulfate and potassium sulfate. Contained 22% S, 18% K, 11% Mg (International Minerals and Chemical, Terre Haute, IN).

[4]Elanco Animal Health, Greenfield, IN.

[5]Calculated based on NRC tabular values (NRC, 1984).

gus- vs. Wagyu-sired cattle on feedlot performance, carcass yield, and quality grades using the USDA (1997) and Japan Meat Grading Association (JMGA, 1989) systems, and tenderness.

MATERIALS AND METHODS

Research protocols regarding animal care followed guidelines recommended in the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1998).

Animals and Treatments

Thirty-nine spring-calving Angus cows produced Angus- and Wagyu-sired steers (n = 9 vs. 11, respectively) and heifers (n = 8 vs. 11, respectively). Angus- and Wagyu-sired calves were early weaned at an average of 138 ± 5 d and transported to the Ohio Agricultural Research and Development Center, Wooster. The calves were housed in individual pens and adapted over a 14-d period to a high-concentrate, corn-based diet containing 65% whole shelled corn, 15% corn silage, 12.4% soybean meal, and 7.6% vitamin/mineral supplement on a DM basis (Table 1). Body weights were recorded at 28-d intervals. The average initial BW for Angus- and Wagyu-sired cattle were 158.4 and 142.2 kg (±8.6 kg), respectively. The slaughter endpoint was set at a BW of 535 kg for heifers and 560 kg for steers. This common slaughter end point between sire breeds was selected to allow comparison of composition and characteristics of carcasses of the same average BW from animals killed at the same average final BW. Cattle were slaughtered in 2 groups for each sire breed group at The Ohio State University's Meat Science Laboratory located in the Department of Animal Sciences Building, Columbus.

Carcass Measurements

Carcasses were chilled for 48 h postmortem and cut between the 12th and 13th rib for USDA (1997) carcass measurements, and the 6th and 7th rib for JMGA (1989) carcass measurements. Carcass measurements for USDA yield grade and boneless, closely trimmed retail cuts percentage included HCW, 12th-rib subcutaneous fat thickness, 12th-rib LM area (**LMA**), and KPH fat percentage. Maturity and marbling scores were also determined for USDA quality grade (USDA, 1997). At the 6th rib, rib thickness, subcutaneous fat thickness, and LMA were measured to determine JMGA yield percentage (JMGA, 1989).

Objective color measurements (L*, a*, and b*) of the LM surface at the 6th and 12th rib were obtained at 48 h postmortem using a Minolta Chroma Meter CR-300 colorimeter (Minolta Corp., Osaka, Japan). Subcutaneous fat color measurements were taken on each carcass at the 12th rib.

Warner-Bratzler Shear Force

Two steaks (2.54 cm) were removed from the short loin at approximately 48 h postmortem, vacuumed-packaged, aged 72 h and 14 d postmortem, and frozen to later analyze for Warner-Bratzler shear force (AMSA, 1995). Steaks were thawed for 24 h at 4°C before cooking. An impingement oven (Lincoln Impinger, Food Service Products Inc., Fort Wayne, IN) was used to cook steaks for 11 min at 176°C to an internal temperature of 66°C. Steaks were weighed to determine cooking loss and then cooled to room temperature. Six 1.3-cm cores were removed parallel to the muscle fibers. The mean of 6 cores was used in the statistical analysis. Due to product loss in the freezer before analysis, shear force values were not obtained for 72-h steaks from Angus-sired heifers.

Ether Extract

The LM from the 12th and 6th rib locations was removed from the right side of each carcass at approximately 48 h postmortem, trimmed of external fat, ground (Hobart model 4822, Hobart Co., Troy, OH) 3 times, and subsampled for determination of moisture and ether-extractable lipid (AOAC, 1996).

Statistical Analysis

All data were analyzed using PROC MIXED (SAS Inst. Inc., Cary, NC). Model included effects of sire

Table 2. Effects of sire breed on feedlot performance

Item	Angus	Wagyu	SEM	*P*-value
Weaning wt, kg	158.4	142.2	8.6	0.07
Weaning age, d	140	137	5	0.57
ADG, kg/d	1.43	1.15	0.03	<0.0001
DMI, kg	7.56	7.02	0.23	0.03
G:F, kg/kg	0.175	0.180	0.004	<0.0001
Final BW, kg	549.5	541.3	12.8	0.52
Days on feed, d	272	349	3	<0.001
Age at slaughter, d	414	485	5	<0.0001

breed, sex, and sire breed × sex interaction. Sire breed least squares means are reported when sire breed × sex interaction was not significant ($P > 0.05$). Warner-Bratzler shear values were corrected for final cooking temperature. Chi-square analysis with FREQ procedure was used to test for the effect of sire breed on distribution of USDA quality grade.

RESULTS AND DISCUSSION

Feedlot Performance

Feedlot performance, carcass characteristics and tenderness did not result in significant sire breed × sex interactions, and means presented are the main effect of sire breed. Cattle from both sire groups were weaned at a similar ($P = 0.57$) average age of 138 ± 5 d (Table 2). Wagyu-sired calves tended to be lighter ($P = 0.07$) in initial BW upon feedlot entry, which is similar to observations by Mir et al. (1997, 1999). In contrast, Wertz et al. (2002) reported greater initial BW for Wagyu-sired calves; however, these calves were weaned at an older age. In the present study, Wagyu-sired calves had a decreased ($P < 0.03$) DMI and ADG and a greater ($P < 0.0001$) G:F ratio compared with Angus-sired calves. As a result of the less BW gain, Wagyu-sired calves remained on feed for an additional 77 d ($P < 0.001$) and were slaughtered at an older age ($P < 0.0001$) than Angus-sired calves.

Wertz et al. (2002) reported reduced feed efficiency, but no difference in DMI or ADG when Wagyu-sired were compared with Angus-sired heifer calves. In contrast, early weaned Wagyu-influenced steers tended to be more efficient compared with British-influenced counterparts (Myers et al., 1999a). The difference in efficiency was attributed partially to more subcutaneous fat cover on Wagyu-sired carcasses; however, in the present study Angus- and Wagyu-sired calves had a similar fat thickness at slaughter. Myers et al. (1999a) reported Wagyu vs. British steers consumed less feed, with a tendency to require more feed per kilogram of BW gain. This resulted in Wagyu-sired steers tending to require more days on feed; however, total feed consumed was similar between sire breeds. These studies indicate Wagyu-influenced cattle require more days on feed than British-influenced counterparts due to a slower rate of growth resulting from decreased daily feed intake.

Carcass Characteristics

As expected, based on the work of Myers et al. (1999a,b), subcutaneous 12th-rib fat thickness was not different ($P = 0.50$) between Wagyu-sired and Angus-sired calves at a similar ($P = 0.92$) HCW (Table 3). Wagyu-sired calves tended to have a larger ($P = 0.08$) 12th-rib LMA and had a greater KPH percentage ($P < 0.0001$). Conflicting results have been published regarding LMA in Wagyu-influenced calves. Several studies (Myers et al., 1999a,b; Wheeler et al., 2004; Lunt et al., 2005) reported smaller LMA in early and normal-weaned Wagyu- vs. British-influenced steers. Whereas Xie et al. (1996b) and Lunt et al. (1993) found similar results to our study with a larger LMA per unit of carcass weight in Wagyu- vs. Angus-sired steers.

Boneless trimmed retail cuts percentage and USDA yield grade were not different ($P > 0.20$) between sire breeds. Wheeler et al. (2004) observed no change in yield grade at the same fat thickness, whereas yield grade was numerically greater for Wagyu-than Angus-sired calves when analyzed at the same carcass weight. In studies where LMA was larger and fat thickness was similar or less, a decreased numeric yield grade was reported (Xie et al., 1996b; Myers et al., 1999a; Lunt et al., 2005) when compared with Angus contemporaries. Myers et al. (1999b) also reported a lesser percentage of USDA yield grade 3 or greater in carcasses from Wagyu- vs. British-sired calves.

According to procedures of the Japan Meat Grading Association percentage yield of boneless trimmed wholesale cuts was evaluated at the 6th rib. Carcasses from Wagyu-sired cattle had smaller LMA ($P = 0.02$) and less ($P < 0.0001$) 6th-rib fat thickness (Table 3). Japanese yield percentage was greater ($P = 0.007$) for Wagyu-sired carcasses. These results are dissimilar to those of the Wagyu- and Angus-sired carcass measurements collected at the 12th rib.

Simple correlations ($n = 39$) between 6th- and 12th-rib IMF ($r = 0.86$), and between marbling score and 6th- and 12th-rib IMF ($r = 0.77$ and 0.85, respectively) were significant ($P > 0.001$; data not presented in tabular form). Harris et al. (1995) reported similar results with a positive relationship in IMF at both locations in the LM. Carcass measurements for fat thickness ($r = 0.57$) and LMA ($r = 0.14$) at the 6th and 12th rib were not ($P > 0.05$) significantly correlated with each other. In contrast, Harris et al. (1995) reported a positive cor-

Table 3. Effects of sire breed of USDA and Japan Meat Grading Association yield measurements

Item	Angus	Wagyu	SEM	*P*-value
HCW, kg	343.1	342.3	6.6	0.92
12th rib				
Fat thickness, cm	1.85	1.72	0.19	0.50
LMA, cm^2	76.6	80.5	2.1	0.08
KPH, %	2.24	3.09	0.16	<0.0001
USDA yield grade	3.86	3.63	0.19	0.23
Boneless trimmed retail cuts,[1] %	47.86	48.21	0.54	0.51
6th rib				
Fat thickness, cm	4.93	2.92	0.16	<0.0001
LMA, cm^2	41.42	37.91	1.41	0.02
Rib thickness, cm	6.81	6.91	0.21	0.73
Japanese yield,[2] %	59.15	59.84	0.18	0.007

[1]Boneless trimmed retail cuts = 51.34 – (14.68 × 12th-rib adjusted fat thickness, cm) – (0.0041 × HCW, kg) – (0.462 × percentage KPH fat) + (4.774 × 12th-rib LM area, cm^2).

[2]Japanese yield = 67.37 + (0.130 × 6th-rib LM area, cm^2) + (0.667 × 6th-rib thickness, cm) – 0.025 × cold left side weight, kg) – (0.896 × 6th-rib subcutaneous fat thickness, cm).

relation between 12th and 6th rib for ribeye area and subcutaneous fat thickness. However, the study conducted by Harris et al. (1995) used only Angus-sired steers; the relationship among carcass traits between the 6th and 12th rib has not been reported in Wagyu-influenced cattle.

Wagyu genetically influenced cattle have been well characterized to deposit more intramuscular and less subcutaneous fat (Lunt et al., 1993; Xie et al., 1996b; Mir et al., 1999; Wheeler et al., 2004). As expected, a greater USDA marbling score was observed for Wagyu- than Angus-sired calves as well as a greater distribution ($P = 0.009$) of USDA Prime carcasses (Table 4). In addition, no carcasses from Wagyu-sired calves graded less than average Choice ($P < 0.01$) compared with 26.3% of those from Angus-sired calves. Intramuscular fat content was 27 and 23% greater ($P < 0.02$) at the 6th and 12th rib, respectively, for Wagyu-sired calves. Myers et al. (1999b) also reported a greater marbling score and percentage of carcasses from Wagyu-sired calves grading USDA Choice and Prime at a similar 12th-rib fat thickness. These results are contrary to a similar study by Myers et al. (1999a) and Wertz et al. (2002) who reported no difference in marbling score or distribution of USDA quality grade at a constant fat thickness in early weaned Wagyu-sired steers and heifers. However, a small number of observations in these 2 studies may have limited the statistical power to detect breed differences in marbling score. Additionally, the genetic potential of sires used in previous studies compared with this study could have contributed to different results.

Lean and Fat Color Characteristics

Lean color differences were detected at the 12th rib, but these differences were not significant at the 6th rib (Table 5). Lean color was less red ($P = 0.001$) and yellow ($P = 0.002$) at the 12th rib in carcasses from Wagyu-sired steers. In contrast, Ozawa et al. (2000) observed no difference in color scores in carcasses from 100% Wagyu steers at the 6th rib with a range of 12 to 27% IMF. Additionally, Mir et al. (1999) reported no difference in meat color comparing 0, 50, and 75% Wagyu-influenced steers. Although breed of sire resulted in significant differences in lean a* and b* values in this study, it is questionable if the magnitude of these differences would have practical implications in the retail marketplace.

One of the components to JMGA meat quality score is fat color, luster, and quality where a lighter, less-red fat color is deemed as more desirable. Subcutaneous fat color was lighter ($P < 0.0001$) and more yellow ($P < 0.0001$) in carcasses from Wagyu-sired calves. The light-

Table 4. Effects of sire breed on intramuscular fat (IMF)

Item	Angus	Wagyu	SEM	*P*-value
USDA marbling score[1]	594	771	41	0.0001
12th-rib IMF, %	10.5	12.9	1.0	0.02
6th-rib IMF, %	11.9	15.1	0.9	0.002
USDA quality grade,[2] %				
Prime	21.1	65.0		0.006
Upper 2/3 Choice	52.6	35.0		0.27
Lower 1/3 Choice	26.3	0.0		0.01

[1]300 = Slight^0; 400 = Small^0; and 500 = Modest^0.

[2]Determined by chi-square analysis.

Table 5. Effects of sire breed on lean and fat color measurements, cooking loss, and tenderness

Item	Angus	Wagyu	SEM	P-value
12th rib				
L*	37.50	37.82	0.67	0.63
a*	22.16	20.51	0.34	0.001
b*	8.32	7.48	0.18	0.002
6th rib				
L*	38.58	39.01	0.71	0.55
a*	22.76	21.95	0.66	0.23
b*	8.66	8.16	0.36	0.17
Subcutaneous fat				
L*	67.35	69.79	0.55	<0.0001
a*	12.92	13.50	0.35	0.23
b*	15.29	17.12	0.29	<0.0001
Cooking loss, %				
72 h	26.5	16.8	1.0	<0.0001
14 d	21.3	18.2	1.0	0.006
Warner-Bratzler shear force, kg				
72 h	4.3	4.3	0.6	0.99
14 d	3.1	3.2	0.2	0.57
Tenderness rate, kg/d	0.01	0.01	0.04	0.98

er fat color would be more desirable in JMGA grading specifications, whereas the more yellow fat color would be considered less favorable.

Tenderness

Cooking loss was significantly less ($P < 0.005$) in steaks from Wagyu-sired calves at 72 h and 14 d (Table 5), and a negative correlation (r = −0.58 and −0.48; $P < 0.005$) was found between 72-h cooking loss and IMF at the 6th- and 12th-rib interface, respectively (data not reported in tabular form). These results are in agreement with Ozawa et al. (2000) who reported a negative correlation between cooking loss and IMF content in Japanese Black steers. However, Myers et al. (1999b) found no difference in cooking loss in early weaned Wagyu-sired calves when compared with British-crossbred contemporaries. The difference in results between these 2 studies may be partially explained in that Myers et al. (1999b) included Continental genetics in their cows and reported a 76-unit improvement in marbling score between carcasses from British-sired (Small^{63}) and Wagyu-sired (Modest^{39}) calves vs. a 177-unit improvement (Modest^{94} to Slightly Abundant^{71}) in marbling score for carcasses from Wagyu-sired calves in the current study.

As expected, steaks from both sire breeds in the current study were more tender at 14 d than at 72 h of aging. These results concur with Xie et al. (1996a) who reported aging beef ribeye steaks (10 vs. 2 d) from Wagyu-sired steers improved tenderness, as well as sensory panel scores for juiciness and tenderness. Warner-Bratzler shear force values were not different ($P > 0.05$) between steaks from Wagyu- or Angus-sired carcasses within each aging period (72 h and 14 d). These results are in agreement with those of Myers et al. (1999b) and Wheeler et al. (2004) who reported that shear force of steaks from Angus- and Wagyu-sired steers were not different at 14 d. However, Wheeler et al. (2004) also reported that shear force of steaks from Angus- and Wagyu-sired steers were less than those of steaks from other sire breeds in that study (Hereford, Norwegian Red, Swedish Red and White, and Friesian). Because there were no differences in shear force within aging periods, rate of tenderization for steaks between sire groups was also similar ($P > 0.05$). In contrast to these results, Kuber et al. (2004) reported an increased ($P < 0.05$) rate of postmortem tenderization for steaks from Wagyu-sired calves; however, their study was comparing steaks from Wagyu, Wagyu × Limousin, and Limousin carcasses.

Platter et al. (2003) reported that carcasses with a high degree of marbling have less variation in tenderness and greater consumer acceptability and Killinger et al. (2004) reported that steaks in the upper 2/3 USDA Choice were rated more desirable in palatability by consumers than USDA Select steaks. Furthermore, consumers indicated that they were willing to pay more for the upper 2/3 USDA Choice steaks.

Conclusions

Early weaned Wagyu-sired cattle produced greater amounts of IMF than their Angus-sired contemporaries. Combining early weaning programs with Wagyu-sires can increase the percentage of carcasses qualifying for upper 2/3 USDA Choice and Prime and may allow for greater premiums to be captured in a value-based marketing system emphasizing quality (USDA marbling score) with minimal impact on yield grade. However, if retail price is established on tenderness thresholds, using Wagyu sires in early weaning production systems may not result in additional advantages compared with Angus sires, and the additional cost of days on feed needed to reach the desired endpoint for Wagyu-sired calves may offset the additional revenue. Using Wagyu sires vs. Angus sires on British-based commercial cows combined with early weaning management strategies has the potential to produce greater marbling but is unlikely to significantly enhance tenderness.

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