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Featured Article

Growth performance, carcass characteristics, and fatty acid composition of Angus- and Wagyu-sired finishing cattle fed for a similar days on feed or body weight endpoint

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Abstract

This study evaluated the feedlot performance, carcass characteristics, and fatty acid (**FA**) composition of Wagyu-sired and Angus-sired cattle at a similar days on feed **(D)** or body weight **(B)** endpoint. Wagyu-sired steers and heifers (**WA**) from two different sires, selected for either growth (**G**) or marbling (**M**), were compared with Angus-sired steers (**AN**, *n* = 13) in two independent incomplete-block design experiments at a similar days on feed (**DOF**; **WA-GD**, *n* = 9; **WA-MD**, *n* = 12) in experiment 1 or similar final body weight (**BW**; **WA-GB**, *n* = 9; **WA-MB**, *n* = 13) in experiment 2. Cattle were offered a corn silage-based growing diet for 119 d before being transitioned over 3 wk to a finishing diet. Data were analyzed as a randomized incomplete block design. In experiment 1, AN and WA-GD cattle had a greater ($P < 0.01$) off-test BW and average daily gain (**ADG** $P < 0.04$) than WA-MD cattle and AN had a greater dry matter intake (**DMI**; $P < 0.02$) than WA-GD and WA-MD cattle. The AN and WA-GD cattle had a greater carcass weight ($P < 0.02$) than WA-MD cattle. Percent kidney, pelvic, and heart fat (**KPH**) was greatest ($P < 0.01$) for WA-MD cattle, followed by WA-GD cattle, and lastly AN cattle. Total lipid ($P < 0.03$) and polyunsaturated FA (**PUFA**; $P < 0.01$) percentage were greater for WA-MD-cattle than AN and WA-GD cattle, as they tended ($P = 0.11$) to have the greatest 12th rib marbling score. In experiment 2, AN-cattle needed fewer ($P < 0.01$) DOF and had a greater ($P \leq 0.02$) ADG, DMI, and gain:feed than WA-GB- and WA-MB-cattle. The WA-MB-cattle had a greater ($P < 0.01$) 12th and 6th rib marbling score, USDA quality grade, and 6th rib backfat thickness than AN-cattle. Compared with AN cattle, WA-GB cattle had a greater ($P \leq 0.01$) percent KPH and lesser ($P \leq 0.03$) rib thickness. The WA-MB-cattle had a greater ($P \leq 0.01$) concentration of total lipid and PUFA than AN- and WA-GB-cattle, and lesser saturated FA (**SFA**; $P < 0.01$) concentration than AN-cattle in the longissimus muscle (**LM**). The 6th rib location of the LM had a greater ($P \leq 0.01$) percentage of total lipid and SFA, but less ($P < 0.03$) MUFA compared with the 12th rib location. In conclusion, Wagyu-sired cattle selected for marbling potential had a lesser ADG, DMI, more marbling, more PUFA, and less SFA in the LM than Angus-sired cattle regardless of slaughter endpoint. Wagyu-sired cattle selected for growth potential had a similar ADG and carcass characteristics compared with Angus-sired cattle when fed for a similar number of days on feed.

Lay Summary

Wagyu-sired steers and heifers (**WA**) from two different sires, selected for either growth (**G**) or marbling (**M**), and Angus-sired steers (**AN**) were fed for a similar days on feed (**D**) or to a similar final body weight (**B**) in two independent experiments. In experiment 1, Angus-sired steers were compared with Wagyu-sired steers and heifers when fed for a similar number of days on feed (**DOF**; **WA-GD** and **WA-MD**) and in experiment 2, AN were compared with Wagyu-sired steers and heifers at a similar final body weight (**BW**; **WA-GB** and **WA-MB**). In experiment 1, AN and WA-GD cattle had a greater rate of gain and final BW compared with WA-MD cattle. AN cattle consumed more feed compared with Wagyu-sired cattle. WA-MD had the greatest amount of kidney fat and polyunsaturated fatty acid (**FA**) compared with AN and WA-GD cattle. In experiment 2, AN cattle had a greater rate of gain, feed intake, with fewer DOF compared with Wagyu-sired cattle. At a similar final BW, WA-MB cattle deposited more kidney fat, marbling at the 6th- and 12th-rib, and backfat at the 6th-rib compared with AN cattle. The FA profile of the longissimus muscle from WA-MB cattle had more polyunsaturated FA, with less saturated FA compared with AN cattle. The resulting feedlot performance and carcass characteristics vary depending on the selection of Wagyu sire for growth or marbling ability.

Key words: age, body weight, fatty acid, feedlot, Wagyu

Abbreviations: IM: intramuscular; BW: body weight; FA: fatty acid; DOF: days on feed; AN: Angus-sired steers; WA-GD: Wagyu-sired steers and heifers selected for growth, slaughtered at a similar age and days on feed; WA-MD: Wagyu-sired steers and heifers selected for marbling, slaughtered at a similar age and days on feed; WA-GB: Wagyu-sired steers and heifers selected for growth, slaughtered at a similar body weight; WA-MB: Wagyu-sired steers and heifers selected for marbling, slaughtered at a similar body weight; DM: dry matter; HCW: hot carcass weight; YG: yield grade; BFT: back fat thickness; LM: longissimus muscle; KPH: kidney, pelvic, heart fat; QG: quality grade; BCTRC: boneless closely trimmed retail cuts; RT: rib thickness; SC: subcutaneous; FA: fatty acid; GLC: gas liquid chromatography; SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid; SEM: standard error of the mean; ADG: average daily gain; DMI: dry matter intake; G:F: gain to feed ratio

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Introduction

The Angus breed is highly recognized for its production of highly marbled, high-quality beef relative to other common cattle breeds in the United States (Kuehn and Thallman, 2017). However, the Wagyu breed, originally from Japan, has received increased interest in the United States due to its superior ability to deposit intramuscular (**IM**) fat, known as marbling. Beef production management is very different between the United States and Japan. In the United States, cattle are placed into a feedlot and fed a high concentrate, grain-based diet as calves, either shortly after weaning (~8 mo of age) or as yearlings (~12-16 mo of age), until the group or pen average reaches either a desired level of finish/fat thickness or body weight (**BW**; Drouillard, 2018). In Japan, cattle are placed in the feedlot, where they are offered a low vitamin A diet to enhance marbling deposition and are managed to grow at a slower rate than cattle in the United States (Oka et al., 1998a, 1998b; 2004; Gotoh et al., 2014). With slower growth rates of 0.8 to 0.9 kg/d, Wagyu steers achieve average body weights of ~750 kg at slaughter in Japan (Motoyama et al., 2016). At ~11 mo of age, Wagyu cattle receive a low-concentrate diet until they reach 18 mo of age (~210 d) and are subsequently transitioned to a high-concentrate diet until they reach 26 to 30 mo of age (~240 to 360 d) before slaughter (Gotoh et al., 2014). In Japan, Wagyu cattle are typically raised to a similar age at slaughter to ensure they have deposited sufficient IM fat to produce extremely high-marbled beef. However, marbling deposition from Wagyu cattle can vary between the four breeds (Japanese Black, Japanese Brown, Japanese Shorthorn, and Japanese Polled) and the different bloodlines popular in different prefectures of Japan (Motoyama et al., 2016). In addition to their propensity to deposit IM fat, Wagyu cattle have been reported to have a unique fatty acid (**FA**) profile which contributes to their fat's softness, palatability attributes, and health benefits when consumed (Smith, 2016). Although questions remain whether Wagyu cattle can deposit greater amounts of marbling compared with Angus cattle when raised to different slaughter endpoints in a U.S. beef production system (Lunt et al., 2005). The hypothesis of the present study was that Angus-sired cattle would have a greater rate of gain and amount of marbling at a similar age and days on feed (**DOF**) endpoint; however, Wagyu-sired cattle would have a greater marbling score and more desirable fatty acid composition compared with Angus-sired cattle when allowed additional time to reach a similar BW endpoint. The objective of this study was to compare the feedlot performance, carcass characteristics, and fatty acid composition of Angus- and Wagyu-sired cattle when raised to a similar age and DOF or BW endpoint in a midwestern U.S. beef production system. Additionally, a secondary objective was to determine if Wagyu sire, selected for either growth or marbling genetic potential, results in offspring that perform differently in the feedlot and produce different carcass characteristics.

Materials and Methods

Animal procedures and husbandry practices were approved by the Institutional Animal Care and Use Committee (IACUC; protocol number 2015A00000093) of The Ohio State University and followed the guidelines recommended in the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 2010).

Experiment 1 treatments (constant DOF comparison)

Experiment 1 was designed to compare similarly aged Angus- and Wagyu-sired cattle, produced from SimAngus dams, when fed for a similar number of days (**D**). Angus-sired steers (**AN**; *n* = 7) were sired by GAR Sunrise (registration #: 16933958), a sire selected for a combination of genetic growth and marbling potential. At the time of the study, GAR Sunrise ranked in the top 15% for yearling weight and top 4% for marbling within the Angus breed. Angus-sired heifers were being utilized as replacement females in the cow herd, and therefore, unavailable for the experiment. Wagyu-sired steers (*n* = 5) and heifers (*n* = 4) selected for growth (**G**) potential were sired by LMR Fukutsuru 729T (**WA-GD**; registration #: FB7480). Wagyu-sired steers (*n* = 5) and heifers (*n* = 7) selected for marbling (**M**) potential were sired by OW Yasufuku 24K 229Y (**WA-MD**; registration #: FB13141). Angus-sired steers, WA-GD, and WA-MD cattle were blocked (*n* = 7) by receiving BW to maintain a similar number of DOF. Once the AN steer in the blocking criteria reached the target off-test BW endpoint of 612 kg (618 ± 8.60 kg) the block of cattle was removed for slaughter.

Experiment 2 treatments (constant BW comparison)

Angus-sired steers (AN) and Wagyu-sired cattle from SimAngus dams were compared at a similar BW endpoint (**B**). As stated in experiment 1, Angus-sired heifers were unavailable for the experiment because they were being utilized as replacement females in the cow herd. Angus-sired steers, Wagyu-sired steers, and Wagyu-sired heifers were removed from the feedlot for slaughter after reaching the target off-test BW of 612 kg (616 ± 7.09 kg), 612 kg (614 ± 15.6 kg), and 566 kg (572 ± 8.68 kg), respectively. Wagyu-sired heifers were removed at a lesser BW to produce a comparable carcass composition to steers, because heifers reach physiological maturity earlier than steers (Mukhoty and Berg, 1971). Angus-sired steers (AN) were sired by GAR Sunrise (*n* = 7) and Carter Blackfoot 307 (registration #: 17847776; *n* = 6), both sires selected for a combination of genetic growth and marbling potential. At the time of the study, GAR Sunrise and Carter Blackfoot 307 ranked in the top 15 and 20% for yearling weight and top 4, and 30% for marbling, respectively, within the Angus breed. Wagyu-sired steers (*n* = 4) and heifers (*n* = 5) selected for growth potential were sired by LMR Fukutsuru 729T (**WA-GB**) and Wagyu-sired steers (*n* = 5) and heifers (*n* = 8) selected for marbling potential were also sired by OW Yasufuku 24K 229Y (**WA-MB**).

Feeding and management

Cattle were born from SimAngus dams at the Jackson Agricultural Research Station (**JARS**; Jackson, OH) in March of 2017. A timed artificial insemination protocol was used to breed cows randomly with one of the four sires used in the present study on the same day. Calves were weighed and weaned at 7 mo of age [205 ± 7.13 d of age (**DOA**)]. Calves were backgrounded for 49 d with free choice hay and a concentrate pellet [consisting of approximately 54% ground corn, 21%, corn gluten feed, 18% low-fat dried distillers grain, 3% soybean meal, 3% animal-vegetable fat blend, and the remaining 1% consisting of Amaferm (BioZyme, St. Joseph, MO), vitamins, and minerals], before being transported to the Ohio Agricultural Research and Development Center (**OARDC**; Wooster, OH) feedlot. Upon receiving at the OARDC feedlot, calves were weighed, ear-tagged, and administered Inforce 3 (Zoetis, Parsippany, NJ) for the prevention of respiratory disease and Vetmetric pour-on (MWI veterinary supply; Northern Ireland) to protect against parasitic infection. Calves were placed into individual pens (2.6 × 1.5 m) consisting of concrete slatted floors, with a 1.5 m long concrete feed bunk, and ad libitum access to clean, fresh water. No growth-promoting implants were administered to prevent their potential interference with marbling deposition (Chung et al., 2012; Smith et al., 2017).

Diets were formulated with a mixture of feedstuffs to meet the nutrient requirements of growing and finishing beef cattle (NASEM, 2016; Table 1), with the exception of excluding vitamin A from the supplement to improve marbling (Pickworth et al., 2012). Cattle were offered a growing diet for approximately 4 mo (119 d) and transitioned to the finishing diet, which they consumed until removal for slaughter. The transition period consisted of 4 diet changes over a three-week period where 25% of the growing diet was replaced by the finishing diet until achieving the finishing diet composition. Daily feed allocation and feed refusals were weighed prior to feeding to record individual feed intake. Daily feed allocation used a slick bunk feeding management strategy. Feed samples were collected and saved every week to determine dry matter (**DM**) percentage (AOAC, 1984) and a composite sample of each dietary ingredient was analyzed for nutrient composition (Rock River Laboratory Inc., Wooster, OH). Body weight measurements were collected prior to feeding and recorded as one-day weights, where weaning BW was collected at weaning, receiving BW was collected at the OARDC feedlot upon arrival, and off-test BW was collected at the OARDC feedlot before being transported to the Ohio State University abattoir (Columbus, OH).

Table 1. Composition (%) of diets offered during the study on a dry matter basis

	Growing	Finishing
Ingredient		
Whole shelled corn	17.50	55.00
DDGS	17.50	10.00
Corn silage	55.00	25.00
Supplement	10.00	10.00
Ground corn	1.12	1.51
Soybean meal	5.00	5.00
Digest more [1]	0.78	0.39
Limestone	1.10	1.10
White salt	1.00	1.00
Urea	0.50	0.50
Vit. A, 30,000 IU/g	0.00	0.00
Vit. D, 3,000 IU/g	0.01	0.01
Vit. E, 44 IU/g	0.02	0.02
Selenium, 201 ppm	0.14	0.14
Potassium chloride	0.30	0.30
Copper sulfate	0.01	0.01
Zinc sulfate	0.02	0.02
Magnesium Sulfate	0.01	0.01
Analyzed composition		
Crude protein, %	14.22	12.90
NDF, %	28.18	17.09
Fat, %	3.71	3.59
Ca, %	0.52	0.45
P, %	0.35	0.33
NEm, Mcal/kg	2.01	2.21
NEg, Mcal/kg	1.35	1.52

[1]Amaferm (BioZyme, St. Joseph, MO).

Carcass data collection

The day after transport from the feedlot, final BW was collected at the abattoir prior to slaughter, and afterwards, hot carcass weight (**HCW**) was collected. Carcasses were allowed to hang for 19.4 ± 3.45 d at 4 ºC. The right side of each carcass was split between the 6th and 7th ribs and between the 12th and 13th ribs to determine Japanese (JMGA, 2008) and USDA (USDA, 2016) yield grade (**YG**), respectively. Between the 12th and 13th ribs, 12th rib backfat thickness (**BFT**), 12th rib longissimus muscle (**LM**) area, estimated percentage kidney, pelvic, and heart fat (**KPH**), 12th rib USDA marbling score, USDA quality grade (**QG**), USDA YG, and calculated percent boneless closely trimmed retail cuts (**BCTRC**) were determined. Between the 6th and 7th ribs, 6th rib BFT, 6th rib LM area, rib thickness (**RT**), 6th rib marbling score, and Japanese YG were determined. The adjustment factor of 2.049 was not applied to the Japanese YG of the Wagyu-sired carcasses in the present study.

Longissimus fatty acid concentration and composition

A thin slice of the LM at the 12th rib (~20 g) and 6th rib (~10 g) interface, free of subcutaneous (**SC**) fat and connective tissue, was collected and frozen for fatty acid (**FA**) composition analysis. Fatty acid and lipid concentrations were determined by ether extraction (AOCS, 2005) and gas liquid chromatography (**GLC**). The FA extraction and methylation processes used in the present study followed the procedures from Folch et al. (1957) and Doreau et al. (2007), respectively. Briefly, longissimus muscle samples were each ground in a blender to create a homogenous sample, from which 1 g of ground tissue was added to a pyrex tube containing a screw cap. Two microliters of an internal standard (0.5 mg 19:0/mL; Nu-Chek Prep, Inc. Elysian, MN), 0.7 mL of 10N KOH in water, and 4.3 mL of methanol were added and the tube vortexed for 120 s. Sample tubes were placed in a 55 °C water bath for 90 min, with 5 s of rigorous shaking taking place every 20 min for each sample. Samples tubes were then placed in an ice water bath to cool samples to room temperature before adding 0.58 mL of 24 N H_2SO_4 to each sample tube. Sample tubes were mixed by inversion and placed back in the 55 °C water bath for 90 min, with 5 s of rigorous shaking taking place every 20 min for each sample. Sample tubes were then cooled in an ice water bath before the addition of 3 mL of hexane. Sample tubes were vortexed and centrifuged for 5 min and the hexane layer was extracted and placed in a GLC vial to be analyzed. All FA methyl esters were separated by GLC using a CP-SIL88 capillary column (100 m × 0.25 mm × 0.2-µm film thickness). Saturated FA percentage was calculated as the sum of 14:0, 16:0, and 18:0. Monounsaturated FA percentage was calculated as the sum of 14:1, 16:1, and 18:1 isomers. Polyunsaturated FA percentage was calculated as the sum of 18:2 isomers and 18:3. Ether extractable lipid and moisture concentration were determined (AOAC, 2005) from ground LM tissue remaining after FA analysis.

Statistical analysis

Statistical analyses were performed using PROC MIXED in SAS (SAS Inst. Inc., Cary, NC). The experimental designs of both experiments 1 and 2 were randomized incomplete block designs, with animal as the experimental unit. The statistical model used for pre-feedlot performance, feedlot performance, and carcass data was: $Y_{ij} = \mu + T_i + s_j + e_{ij}$, where T_i = treatment as a fixed effect, and the random effect of s_j = sex (incomplete blocking criteria), and e_{ij} = random error. The statistical model used for FA composition was: $Y_{ijk} = \mu + T_i + L_j + TL_{ij} + s_k + e_{ijk}$, where L_j = location (6th or 12th rib) and TL_{ij} = treatment × location as fixed effects. The REPEATED statement was used to determine the effect of FA composition by location within the LM, and the covariance structure with the lowest Bayesian information criterion was used. In experiment 1, slaughter block was added to the performance, carcass, and FA composition models as a random effect, except for performance measurements collected before feedlot entry. The LSMEANS and PDIFF statements were used to record treatment least square mean estimates, standard errors (SEM), and distinguish differences between the treatment levels. To determine if total FA lipid percentage influenced the percentage of each FA, it was tested in the model as a covariate to determine if it had a significant ($P \leq 0.05$) effect. A significance of fixed effects was established at $P \leq 0.05$ and tendencies are discussed in the text at $0.05 < P < 0.15$.

Results and Discussion

This study aimed to compare Angus- and Wagyu-sired cattle with different genotypes, selected for growth or marbling potential, at a similar age and DOF (experiment 1) or final body weight (experiment 2). The birth weight of calves born from Angus and Wagyu sires (34.4 ± 5.21 kg) was not different ($P = 0.17$, experiment 1; $P = 0.68$, experiment 2); however, gestation length of Wagyu-sired calves was 6 to 8 d greater compared with Angus-sired calves ($P = 0.16$, experiment 1; $P = 0.03$, experiment 2). Reciprocally crossed calves from Angus and Wagyu cows were reported to have a lesser birth weight from Wagyu cows (30 kg) compared with Angus cows (38 kg), while Wagyu-sired calves also had a lesser birth weight (33 kg) compared with Angus-sired calves (35 kg; Rogers et al., 2002). The dam appears to have a greater influence on calf birth weight compared with the sire and this may have been the reason for the lack of differences observed for calf birth weight in this study (experiments 1 and 2). In agreement with other research, the reported gestation length of Wagyu-sired calves is greater compared with other breeds of cattle (Casas et al., 2012), with Wagyu cows typically having a gestation length of 289 d (Oyama et al., 2004).

Experiment 1 (constant DOF comparison)

Weaning BW was greater for AN ($P < 0.02$) and WA-GD ($P < 0.02$) calves compared with WA-MD calves (Table 2). The additional time (49 d) spent consuming a backgrounding diet before feedlot entry further exemplified the BW difference between calves in the three treatments, as feedlot receiving weight was different ($P < 0.02$). AN calves tended to have a greater feedlot receiving weight compared with WA-GD ($P = 0.09$) and a greater receiving BW compared with WA-MD ($P < 0.01$). A greater ADG for Angus- and Wagyu-sired calves prior to feedlot entry is supported by the results of many others (Lunt et al., 2005; Radunz et al., 2009; Casas et al., 2012); however, the ADG of Angus-sired and Wagyu-sired heifer calves in a study conducted by Wertz et al. (2002) were not different. When cattle were fed to a similar DOF endpoint of approximately 250 d, the ADG of AN ($P < 0.04$) and WA-GD ($P < 0.03$) cattle had a greater ADG compared with WA-MD cattle (1.2 vs. 1.1 kg/d, respectively). Lunt et al. (1993) reported a greater ADG by Angus steers compared with Wagyu (75% to 85%) crossbred steers (0.9 vs. 0.7 kg/d, respectively) when fed for a targeted rate of gain of 0.9 kg/d over the course of a 552-d feeding period; however, crossbred Wagyu steers were 253 d older and 40 kg heavier than Angus steers at the beginning of the feeding period. Similar to the study conducted by Lunt et al. (1993) and Lunt et al.

Table 2. Feedlot performance of Angus- and Wagyu-sired cattle raised to a similar days on feed (DOF) end point—experiment 1

Item	Treatment [1]			SEM[2]	*P*-value
	AN (*n* = 7)	WA-GD (*n* = 9)	WA-MD (*n* = 12)		
Weaning age, d	210	203	204	2.69	0.16
DOF, d	243	263	250	13.4	0.52
Slaughter age, d	501	515	503	14.0	0.72
Birth weight, kg	33.5	35.5	31.4	2.70	0.17
Weaning weight, kg	239 [a]	235 [a]	220 [b]	11.6	0.02
Receiving weight, kg	272 [a]	257 [a,b]	248 [b]	13.7	0.02
Off-test weight, kg	581 [a]	570 [a]	531 [b]	42.5	0.01
ADG, kg/d	1.21 [a]	1.20 [a]	1.10 [b]	0.115	0.04
DMI, kg/d	8.92 [a]	8.11 [b]	7.87 [b]	0.646	0.02
Total DMI, kg	2,165	2,033	1,950	223	0.09
G:F, kg/kg	0.138	0.148	0.138	0.0050	0.06

[1]A*n* = Angus-sired steers selected for a combination of growth and marbling potential, WA-GD = Fukutsuru-sired Wagyu cattle selected for growth potential, WA-MD = Yasufuku-sired Wagyu cattle selected for marbling potential.
[2]The reported standard error of the mean is the greatest between the different treatments.
[a,b]Treatment lsmean estimates within a row, with a different superscript differ ($P \leq 0.05$).

(2005) reported a greater ADG from Angus steers compared with Wagyu steers (1.25 vs. 1.03 kg/d, respectively) when fed a corn-based diet for a targeted rate of gain of 1.36 kg/d over the course of an 8 mo feeding period. In partial agreement, Wertz et al. (2002) reported a numerically greater ADG for Angus-sired heifers compared with Wagyu-sired heifers (1.07 vs. 0.99 kg/d). As a result of a greater ADG during the constant length feeding period, AN (P < 0.01) and WA-GD (P < 0.01) cattle had a greater off-test BW compared with WA-MD cattle; which is in partial agreement with reported research, as Angus-sired cattle typically have a greater off-test weight compared with Wagyu-sired cattle (Lunt et al., 1993, 2005). A greater ADG observed for AN cattle may be partially due to their greater average daily DMI when compared with WA-GD (P < 0.03) and WA-MD (P < 0.01) cattle. As a result, AN cattle tended to have a greater total DMI (P = 0.09) during the feeding period compared with WA-GD and WA-MD cattle. Interestingly, Angus- and Wagyu-sired calf-fed (9 mo old at feedlot entry) heifers did not have a different daily DMI, but 2-year old (22 mo old at feedlot entry) Angus-sired heifers had a greater DMI compared with 2-year old Wagyu-sired heifers (Wertz et al., 2002), which supports our results. Wertz et al. (2002) reported a greater G:F for 2-year-old Wagyu-sired heifers compared with 2-year old Angus-sired heifers, but a greater G:F for Angus-sired calf-fed heifers compared with Wagyu-sired calf-fed heifers. In partial agreement, WA-GD tended (P = 0.06) to have a greater G:F compared with AN and WA-MD cattle.

Wagyu-sired cattle selected for marbling potential (WAMD) had a lesser HCW compared with AN (P < 0.02) and WA-GD (P < 0.01) cattle due to their lesser ADG, weighing 49 and 43 kg less, respectively (Table 3). Carcasses from WA-GD (P < 0.01) and WA-MD (P < 0.01) cattle had a greater estimated KPH fat percentage compared with carcasses from AN cattle, while carcasses from WA-GD cattle (P < 0.01) had a greater estimated KPH fat percentage compared with carcasses from WA-MD cattle. Additionally, 12th rib marbling score tended (P = 0.12) to differ, with carcasses from WA-MD cattle having a numerically greater marbling score (SLAB^{28} vs. MT$^{52\text{-}55}$) compared with carcasses from AN and WA-GD cattle. Rib thickness at the 6th rib location was not different (P = 0.16) among carcasses from AN, WA-GD, and WA-MD cattle. Lunt et al. (1993) reported similar carcass characteristics at the 6th rib and 12th rib between Angus and Wagyu steers, except for a greater marbling score at the 12th rib for Wagyu steers, even though carcasses from Wagyu steers weighed 41 kg less (426 vs. 467 kg, respectively) compared with Angus steers. Carcasses from calf-fed Wagyu-sired heifers had a greater HCW, percentage of KPH fat, BFT, and a numerically greater marbling score (SLAB^{23} vs. MT^{19}) at the 12th rib when compared with carcasses from calf-fed Angus-sired heifers (Wertz et al., 2002). Xie et al. (1996) reported that Wagyu-sired steers had a greater LM area, percentage of KPH fat, and 12th rib marbling score, but a lesser 12th rib BFT. However, there were differences among Wagyu-sired steers due to sire for 12th rib LM area and 12th rib BFT (Xie et al., 1996). Elias Calles et al. (2000) reported cattle sired by 'new' Wagyu sires imported into the U.S. in 1993 had a greater LM area and marbling score compared with cattle sired by 'old' Wagyu sires imported into the U.S. between 1974 and 1976. There were no differences for LM area at the 12th (P = 0.66) or 6th rib (P = 0.25) between AN, WA-GD, and WA-MD cattle. The location at which carcass fat is deposited appears to be the greatest difference between AN and WA cattle when fed for a similar number of DOF. In disagreement with these results, Lunt et al. (2005) reported a greater HCW disparity between Angus and Wagyu steers of 71 kg (323 vs. 252 kg, respectively). In addition, carcasses from Angus steers had a 10 cm^2 greater LM area, 0.5 cm greater BFT, 0.2% greater KPH fat, and a greater percentage of LM lipid compared with carcasses from Wagyu steers (Lunt et al., 2005). However, Wagyu steers in the study conducted by Lunt et al. (2005) entered the feedlot at a lesser BW (39 kg) compared with Angus steers, and therefore, were compared physiological maturities that were different.

When fed for a similar number of DOF, WA-MD cattle had a greater percentage of ether extractable lipid (P < 0.01) and total FA lipid (P < 0.02) when compared with WA-GD cattle, and tended to have greater percentage of ether extractable lipid (P = 0.17) and total FA lipid (P = 0.06) compared with AN cattle (Table 4). The difference between total FA lipid and ether extractable lipid percentage is likely due to losses from glycerol, unmeasured FA, and other ether extractable components in the total FA lipid measurement. Wagyu-sired cattle selected for marbling had a greater percentage of 18:1 trans (P < 0.03, P < 0.01), 18:2 (P < 0.02, P < 0.01), and PUFA (P < 0.05, P < 0.01) in the LM compared with AN and WA-GD cattle, respectively. Angus-sired cattle had a greater percentage of 18:3 in the LM compared with WA-GD (P < 0.01) and WA-MD (P < 0.01) cattle. Xie et al. (1996) reported a greater percentage of 14:0, 14:1, 16:0, and 16:1 in the LM of Wagyu-sired steers compared with Angus-sired steers, while Angus-sired steers had a greater percentage of 18:0, 18:2, PUFA, and PUFA:SFA ratio. This is in disagreement with our results as no treatment differences for 14:0 (P = 0.28), 14:1 (P = 0.30), 16:0 (P = 0.28), 16:1 (P = 0.68), and 18:0 (P = 0.40) were observed for the FA composition of the LM. In addition, WA-MD cattle had a greater percentage of 18:2, PUFA, and tended (P = 0.09) to have a greater PUFA:SFA compared with AN cattle. Fatty acid differences between the two studies are likely due to a combination of things such as diet, genetics, and percent IM fat. Other studies have measured the fatty acid composition between Angus- and Wagyu-sired cattle from components other than the LM, such as digesta, plasma, SC fat, dissected IM fat, and IM fat-free LM (May et al., 1993; Chung et al., 2006).

The MUFA:SFA (P < 0.01) demonstrated an interaction between treatment and LM location. The magnitude of the difference for the MUFA:SFA ratio between the 12th rib compared with the 6th rib was greater for WA-MD cattle (1.08% vs. 1.02%) compared with AN (1.03% vs. 1.01%) and WA-GD cattle (1.02% vs. 1.00%). The MUFA:SFA ratio interaction was likely a result of the percentage of 18:1 cis 9 (P = 0.07) and the percentage of SFA (P = 0.06) tending to exhibit a treatment × LM location interaction. The LM had a greater percentage of ether extractable lipid (P < 0.03) and total FA lipid (P < 0.01) at the 6th rib compared with the 12th rib location. In agreement, Radunz et al. (2009) reported a greater percentage of ether extractable lipid in the LM at 6th rib compared with the 12th rib for carcasses from Angus- and Wagyu-sired cattle. Cook et al. (1964) and Zembayashi et al. (1995) demonstrated that LM lipid concentration is greater at the anterior and posterior ends compared with the medial part of the LM. In addition, the LM had a greater percentage of 18:0 (P < 0.01), 18:1 trans isomers (P < 0.01), and SFA (P < 0.01) at the 6th rib compared with the 12th rib location.

Table 3. Carcass characteristics of Angus- and Wagyu-sired cattle raised to a similar days on feed end point—experiment 1

Item	Treatment [1]			SEM[2]	*P*-value
	AN (*n* = 7)	WA-GD (*n* = 9)	WA-MD (*n* = 12)		
Final weight, kg	555[a]	549[a]	506[b]	44.8	0.01
HCW, kg	353[a]	352[a]	326[b]	32.0	0.02
DP, %	63.73	64.21	64.24	0.799	0.74
KPH, %	2.33[c]	3.35[a]	2.87[b]	0.165	0.01
12th Rib					
LM area, cm^2	84.7	84.1	81.6	5.99	0.66
Backfat thickness, cm	2.14	2.13	1.90	0.308	0.60
USDA YG[3]	3.85	4.09	3.64	0.367	0.45
BCTRC, %[4]	47.79	47.26	48.35	0.855	0.42
USDA QG[5]	12.04	12.23	12.83	0.368	0.17
Marbling score[6]	652	655	728	36.6	0.11
6th Rib					
LM area, cm^2	44.2	42.6	40.8	3.40	0.25
Backfat thickness, cm	2.90	3.12	3.07	0.225	0.62
Rib thickness, cm	7.55	6.75	6.74	0.454	0.16
Japanese YG, % [7]	71.08	70.18	70.34	0.331	0.07
Marbling score[6]	684	694	743	37.1	0.24

[1]AN = Angus-sired steers selected for a combination of growth and marbling potential, WA-GD = Fukutsuru-sired Wagyu cattle selected for growth potential, WA-MD = Yasufuku-sired Wagyu cattle selected for marbling potential.
[2]The reported standard error of the mean is the greatest between the different treatments.
[3]YG = 2.5 + (2.5 × (12th rib fat thickness/2.54)) + (0.2 × % KPH) + (0.0038 × HCW/0.453592)) – (0.32 × (LM area/6.4516)).
[4]BCTRC (boneless closely trimmed retail cuts) = 51.34 – (2.28 × (12th rib fat thickness)) – (0.462 × % KPH) – (0.02 × (HCW)) + (0.1147 × (LM area)).
[5]USDA QG is based on a numeric scale: 11 = average choice, 12 = high choice.
[6]Marbling score is based on a numeric scale: 600-699 = moderate, 700-799 = slightly abundant.
[7]Japanese YG = 67.37 + (0.13 × (LM area/ 6.4516)) + (0.667 × (6th rib fat thickness/ 2.54)) - (0.025 × (carcass side weight/ 0.453592)) - (0.896 × (6th rib thickness/ 2.54)).
[a,b]Treatment lsmean estimates within a row, with a different superscript differ ($P \le 0.05$).

However, the 12th rib location had a greater percentage of 14:1 ($P < 0.01$), 18:1 cis 9 ($P < 0.01$), other 18:1 cis isomers ($P < 0.01$), MUFA ($P < 0.03$), MUFA:SFA ($P < 0.01$), and PUFA:SFA ($P < 0.05$) compared with the 6th rib location of the LM.

Experiment 2 (constant BW comparison)

Weaning weight tended ($P = 0.13$) to be greater for AN calves compared with WA-MB calves, but there was no difference ($P = 0.27$) between AN and WA-GB calves. After the 49 d backgrounding period, AN calves had a greater ($P < 0.01$) receiving weight and WA-GB calves tended ($P = 0.08$) to have a greater receiving weight compared with WA-MB calves (Table 5).

When Angus- and Wagyu-sired cattle were raised to a similar final BW for slaughter (590 kg), WA-GB and WA-MB cattle required additional time on feed ($P < 0.01$) and were older ($P < 0.01$) compared with AN cattle. As a result of a more days on feed, WA-GB and WA-MB cattle had a greater overall DMI ($P < 0.01$) compared with AN cattle. Wagyu-sired cattle had a lesser ADG ($P < 0.01$) and DMI ($P < 0.02$) compared with AN cattle. Angus-sired cattle had a greater G:F compared with WA-MD cattle ($P < 0.01$), with WA-GD cattle being intermediate ($P > 0.13$). In agreement, Radunz et al. (2009) reported a greater DOF and chronological age for Wagyu-sired cattle compared with Angus-sired cattle when slaughtered at an average targeted BW of 548 kg. Wagyu-sired cattle had a lesser ADG, DMI, but a greater G:F compared with Angus-sired cattle (Radunz et al., 2009). On average, Wagyu-sired cattle consumed DM at 1.92% of their BW compared with 2.15% for AN cattle, which is in agreement with results from Radunz et al. (2009) for Wagyu- and Angus-sired cattle (2.05 vs. 2.14 DMI as a % of BW, respectively). The additional time on feed required to reach the targeted final BW by Wagyu-sired cattle in experiment 2 resulted in a decreased average feedlot performance, with an increased average DMI, reduced ADG and G:F compared with the Wagyu-sired cattle in experiment 1.

Allowing WA-GB and WA-MB cattle additional time to reach to the same final BW target as AN cattle resulted in no differences for HCW ($P = 0.51$) among the treatments of cattle (Table 6). Carcasses from WA-MB cattle had a greater DP ($P < 0.03$, $P < 0.03$), 12th rib marbling score ($P < 0.01$, $P < 0.01$), USDA QG ($P < 0.01$, $P < 0.01$), and 6th rib BFT ($P < 0.01$, $P < 0.05$) compared with AN and WA-GB cattle, respectively. Carcasses from WA-GB ($P < 0.01$) and WA-MB ($P < 0.01$) cattle had a greater estimated percentage of KPH fat compared with carcasses from AN cattle. Marbling score at the 6th rib was greater ($P < 0.01$) for carcasses from WA-MB cattle compared with carcasses from AN cattle, with carcasses from WA-GB cattle being intermediate compared with carcasses from WA-MB ($P = 0.15$) and AN ($P = 0.11$) cattle. Carcasses from AN ($P < 0.02$) and WA-MB ($P < 0.03$) cattle had a greater rib thickness at the 6th rib compared with carcasses from WA-GB cattle. The LM area at the 6th rib tended to differ ($P = 0.12$), with carcasses from AN cattle having a numerically greater (9 cm^2) LM area compared with carcasses from WA-GB cattle. This partially led to a greater Japanese

Table 4. Longissimus muscle fatty acid composition of Angus- and Wagyu-sired cattle raised to a similar days on feed end point—experiment 1

Item	Treatment [1]			SEM[2]	Location		SEM [2]	*P*-value		
	AN (*n* = 7)	WA-GD (*n* = 9)	WA-MD (*n* = 12)		6th rib (*n* = 28)	12th rib (*n* = 28)		TRT	LOC	T × L
Ether extractable lipid, %	11.91[ab]	10.52[b]	13.79[a]	1.875	12.80	11.34	1.656	0.02	0.03	0.32
Total fatty acid lipid, %	9.03[ab]	8.65[b]	11.26[a]	1.271	10.60	8.69	1.011	0.03	0.01	0.54
14:0, %	2.93	3.15	3.11	0.159	3.07	3.06	0.130	0.28	0.83	0.39
14:1, %	0.65	0.82	0.68	0.107	0.67	0.76	0.071	0.30	0.01	0.27
16:0, %	27.36	28.18	27.64	0.466	27.80	27.66	0.299	0.28	0.28	0.23
16:1, %	3.71	3.70	3.56	0.206	3.61	3.71	0.171	0.68	0.50	0.76
18:0, %	13.95	13.63	13.12	0.662	13.99	13.14	0.509	0.40	0.01	0.30
18:1 trans, %	1.28[b]	1.15[b]	1.47[a]	0.106	1.37	1.23	0.088	0.01	0.01	0.17
18:1 cis 9, %	40.97	40.67	41.05	0.570	40.69	41.10	0.407	0.78	0.01	0.07
18:1 cis others, %	2.32	2.26	2.81	0.084	2.25	2.36	0.047	0.67	0.01	0.37
18:2, %	2.41[b]	2.30[b]	2.81[a]	0.125	2.49	2.52	0.069	0.01	0.50	0.57
18:3, %	0.24[a]	0.20[b]	0.18[b]	0.012	0.21	0.20	0.008	0.01	0.17	0.29
SFA, %	44.53	44.68	43.75	0.677	44.82	43.82	0.356	0.46	0.01	0.06
MUFA, %	48.88	48.62	49.13	0.688	48.59	49.16	0.472	0.77	0.03	0.71
PUFA, %	2.67[b]	2.50[b]	2.99[a]	0.133	2.71	2.73	0.081	0.01	0.58	0.54
MUFA:SFA	1.02	1.01	1.05	0.029	1.01	1.05	0.015	0.48	0.01	0.01
PUFA:SFA	0.061[ab]	0.056[b]	0.068[a]	0.004	0.061	0.063	0.003	0.01	0.05	0.33

[1]AN = Angus-sired steers selected for a combination of growth and marbling potential, WA-GD = Fukutsuru-sired Wagyu cattle selected for growth potential, WA-MD = Yasufuku-sired Wagyu cattle selected for marbling potential.
[2]The reported standard error of the mean is the greatest between the different treatments.
[a,b]Treatment lsmean estimates within a row, with a different superscript differ ($P \leq 0.05$).

Table 5. Feedlot performance of Angus- and Wagyu-sired cattle raised to a similar body weight end point—experiment 2

Item	Treatment [1]			SEM [2]	*P*-value
	AN (*n* = 13)	WA-GB (*n* = 9)	WA-MB (*n* = 13)		
Weaning age, d	210[a]	204[b]	202[b]	2.54	0.03
DOF, d	235[b]	294[a]	328[a]	15.4	0.01
Slaughter age, d	495[b]	547[a]	579[a]	15.9	0.01
Birth weight, kg	34.6	36.1	34.0	2.63	0.68
Weaning weight, kg	245	236	222	12.3	0.13
Receiving weight, kg	278[a]	264[ab]	244[b]	13.4	0.02
Off-test weight, kg	595	592	590	20.5	0.77
ADG, kg/d	1.36[a]	1.13[b]	1.06[b]	0.043	0.01
DMI, kg/d	9.40[a]	8.17[b]	8.04[b]	0.279	0.01
Total DMI, kg	2164[b]	2360[a]	2627[a]	111	0.01
G:F, kg/kg	0.145[a]	0.139[ab]	0.132[b]	0.0034	0.02

[1]AN = Angus-sired steers selected for a combination of growth and marbling potential, WA-GD = Fukutsuru-sired Wagyu cattle selected for growth potential, WA-MD = Yasufuku-sired Wagyu cattle selected for marbling potential.
[2]The reported standard error of the mean is the greatest between the different treatments.
[a, b]Treatment lsmean estimates within a row, with a different superscript differ ($P \leq 0.05$).

YG for carcasses from AN cattle compared with carcasses from WA-GB ($P < 0.01$) and WA-MB ($P < 0.02$) cattle. In general, carcasses from WA-GB and WA-MB cattle were fatter than carcasses from AN cattle at a similar final BW. In agreement, Radunz et al. (2009) reported a greater percentage of KPH fat, percentage of ether extractable fat at the 6th rib and 12th rib locations, USDA QG, and 12th rib marbling score for Wagyu-sired cattle compared with carcasses from Angus-sired cattle. In disagreement, there was no difference in 12th rib BFT between carcasses from Angus- and Wagyu sired cattle and carcasses from Angus-sired cattle had a greater 6th rib BFT compared with carcasses from Wagyu-sired cattle (4.93 vs. 2.92 cm, respectively; Radunz et al., 2009). Differences in BFT between Angus- and Wagyu-sired cattle in these two studies may be due to differences in genetics between the sires and dams used. Additionally, Angus- and Wagyu-sired cattle

Table 6. Carcass characteristics of Angus- and Wagyu-sired cattle raised to a similar body weight end point—experiment 2

Item	Treatment [1]			SEM [2]	*P*-value
	AN (n = 13)	WA-GB (n = 9)	WA-MB (n = 13)		
Final weight, kg	570	573	570	23.6	0.88
HCW, kg	366	367	373	15.8	0.51
DP, %	64.24^{b}	64.10^{b}	65.39^{a}	0.428	0.04
KPH, %	2.45^{b}	3.61^{a}	3.46^{a}	0.178	0.01
12th Rib					
LM area, cm^2	86.7	84.4	87.6	4.52	0.64
Backfat thickness, cm	2.10	2.44	2.38	0.242	0.48
USDA YG [3]	3.79	4.52	4.32	0.307	0.16
BCTRC, % [4]	47.98	46.26	46.71	0.700	0.14
USDA QG [5]	11.90^{b}	12.32^{b}	13.51^{a}	0.379	0.01
Marbling score [6]	638^{b}	684^{b}	785^{a}	36.1	0.01
6th Rib					
LM area, cm^2	47.4	43.5	45.6	1.64	0.12
Backfat thickness, cm	2.80^{b}	3.20^{b}	3.64^{a}	0.164	0.01
Rib thickness, cm	7.47^{a}	6.66^{b}	7.41^{a}	0.241	0.03
Japanese YG, % [7]	71.36^{a}	70.02^{b}	70.33^{b}	0.234	0.01
Marbling score [6]	653^{b}	721^{ab}	778^{a}	37.6	0.01

[1]A*n* = Angus-sired steers selected for a combination of growth and marbling potential, WA-GD = Fukutsuru-sired Wagyu cattle selected for growth potential, WA-MD = Yasufuku-sired Wagyu cattle selected for marbling potential.
[2]The reported standard error of the mean is the greatest between the different treatments.
[3]YG = 2.5 + (2.5 × (12th rib fat thickness/ 2.54)) + (0.2 × % KPH) + (0.0038 × HCW/0.453592)) − (0.32 × (LM area/6.4516)).
[4]BCTRC (Boneless closely trimmed retail cuts) = 51.34 − (2.28 × (12th rib fat thickness)) − (0.462 × % KPH) − (0.02 × (HCW)) + (0.1147 × (LM area)).
[5]USDA QG is based on a numeric scale: 11 = average choice, 12 = high choice.
[6]Marbling score is based on a numeric scale: 600-699 = moderate, 700-799 = slightly abundant.
[7]Japanese YG = 67.37 + (0.13 × (LM area/ 6.4516)) + (0.667 × (6th rib fat thickness/ 2.54)) − (0.025 × (carcass side weight/0.453592)) − (0.896 × (6th rib thickness/2.54)).
[a,b]Treatment lsmean estimates within a row, with a different superscript differ ($P \leq 0.05$).

may have deposited carcass backfat differently in response to being early-weaned (Radunz et al., 2009).

Wagyu-sired cattle selected for marbling potential (WA-MB) had a greater percentage of ether extractable ($P < 0.01$, $P < 0.01$) and total FA lipid ($P < 0.01$, $P < 0.01$) in the LM compared with AN and WA-GB cattle, respectively (Table 7). In the LM, AN cattle had a greater percentage of 18:0 compared with WA-GB ($P < 0.03$) and WA-MB ($P < 0.01$) cattle, which contributed to AN cattle tending to have a greater percentage of SFA ($P = 0.07$) in the LM when compared with WA-MB cattle. The LM from WA-MB cattle tended to have a greater percentage of other 18:1 cis isomers ($P = 0.07$), MUFA ($P = 0.10$), and MUFA:SFA ratio ($P = 0.07$) compared with AN cattle. The LM of WA-MB cattle also had a greater percentage of 18:2 ($P < 0.01$, $P < 0.04$), PUFA ($P < 0.01$, $P < 0.04$), and PUFA:SFA ($P < 0.01$, $P < 0.02$) compared with the LM from AN and WA-GB cattle, respectively.

The percentage of 18:3 ($P < 0.04$) and MUFA ($P < 0.04$) exhibited treatment × LM location interactions. The LM had a numerically greater percentage of 18:3 at the 12th rib compared with the 6th rib location for WA-MB cattle (0.226% vs. 0.216%), but AN and WA-GB cattle had a numerically lesser percentage of 18:3 in the 12th rib when compared with the 6th rib location (0.242% vs. 0.249% and 0.203% vs. 0.218%, respectively). The magnitude of difference for MUFA percentage between the 12th and 6th rib was greater for WA-MB cattle (51.9% vs. 50.8%, respectively) compared with AN cattle (49.2% vs. 48.7%, respectively), while WA-GB cattle demonstrated the opposite interaction with less MUFA in the 12th rib when compared with the 6th rib of the LM (49.5% vs. 49.9%, respectively). Similar to Exp.1, the LM had a greater ($P < 0.01$) percentage of total lipid at the 6th rib location compared with the 12th rib location. In general, cattle had a greater percentage of 18:0 ($P < 0.01$), 18:1 trans isomers ($P < 0.01$), and SFA ($P < 0.01$) at the 6th rib when compared with the 12th rib location of the LM; whereas the LM at the 12th rib had a greater percentage of 14:1 ($P < 0.01$), 18:1 cis 9 ($P < 0.01$), other 18:1 cis isomers ($P < 0.01$), MUFA ($P = 0.09$), MUFA:SFA ($P < 0.01$), and PUFA:SFA ($P < 0.01$) compared with the 6th rib location. The differences in LM FA composition between the 6th and 12th location were not different between experiments 1 and 2, which demonstrates that the additional DOF for Wagyu-sired cattle did not alter the FA composition throughout the LM.

In conclusion, feedlot performance and carcass characteristics of Wagyu-sired progeny were notably different between Wagyu sires. At a similar age and DOF, Angus-sired and Wagyu-sired cattle selected for growth had a similar ADG that was greater than the ADG of Wagyu-sired cattle selected for marbling. Interestingly, Angus-sired cattle had a greater DMI on a body weight basis when compared with Wagyu-sired cattle. Wagyu-sired cattle selected for marbling were able to deposit a greater amount of IM fat than Angus-sired and Wagyu-sired cattle selected for growth when compared at a similar age and BW endpoint. In addition to a greater percentage of IM fat, Wagyu-sired cattle selected for marbling had

Table 7. Longissimus muscle fatty acid composition of Angus- and Wagyu-sired cattle raised to a similar body weight end point—experiment 2

Item	Treatment [1]			SEM [2]	Location		SEM [2]	*P*-value		
	AN (*n* = 13)	WA-GB (*n* = 9)	WA-MB (*n* = 13)		6th rib (*n* = 34)	12th rib (*n* = 34)		TRT	LOC	T×L
Ether extractable lipid, %	10.40[b]	11.39[b]	15.90[a]	1.197	13.82	11.31	0.828	0.01	0.01	0.65
Total fatty acid lipid, %	7.82[b]	9.34[b]	12.85[a]	0.982	10.72	9.28	0.542	0.01	0.01	0.77
14:0, %	2.81	2.79	2.85	0.190	2.81	2.82	0.168	0.87	0.83	0.31
14:1, %	0.58	0.69	0.74	0.079	0.63	0.71	0.064	0.14	0.01	0.71
16:0, %	26.82	27.42	26.90	0.926	27.10	27.00	0.859	0.50	0.41	0.06
16:1, %	3.46	3.37	3.79	0.228	3.49	3.59	0.159	0.27	0.53	0.24
18:0, %	14.75[a]	13.09[b]	12.00[b]	0.570	13.68	12.88	0.327	0.01	0.01	0.43
18:1 trans, %	1.29	1.21	1.40	0.077	1.37	1.23	0.042	0.19	0.01	0.87
18:1 cis 9, %	41.28	42.10	42.83	1.316	41.92	42.23	1.172	0.28	0.01	0.06
18:1 cis others, %	2.26	2.36	2.59	0.143	2.37	2.43	0.111	0.07	0.01	0.12
18:2, %	2.43[b]	2.52[b]	2.84[a]	0.118	2.57	2.62	0.063	0.02	0.15	0.29
18:3, %	0.25	0.21	0.22	0.029	0.23	0.22	0.025	0.33	0.30	0.04
SFA, %	44.31	43.30	41.77	1.370	43.58	42.69	1.188	0.07	0.01	0.21
MUFA, %	48.92	49.73	51.33	1.520	49.79	50.20	1.340	0.10	0.09	0.04
PUFA, %	2.65[b]	2.73[b]	3.06[a]	0.120	2.79	2.84	0.064	0.02	0.17	0.38
MUFA:SFA	1.03	1.09	1.16	0.065	1.08	1.11	0.056	0.07	0.01	0.23
PUFA:SFA	0.061[b]	0.063[b]	0.074[a]	0.004	0.065	0.067	0.004	0.02	0.01	0.64

[1]AN = Angus-sired steers selected for a combination of growth and marbling potential, WA-GD = Fukutsuru-sired Wagyu cattle selected for growth potential, WA-MD = Yasufuku-sired Wagyu cattle selected for marbling potential.
[2]The reported standard error of the mean is the greatest between the different treatments.
[a,b]Treatment lsmean estimates within a row, with a different superscript differ ($P \le 0.05$).

a more PUFA relative to SFA in the LM. This study demonstrates that Wagyu-sired cattle can be selected to produce superior quality beef with a greater amount of IM fat and a more desirable FA composition compared with Angus-sired cattle at a similar age (16.5 mo.) in a midwestern U.S. beef production system.

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Conflict of Interest Statement

The authors declare no conflict of interest with the present study.

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