Journal of Animal and Veterinary Advances 4 (11): 949-953, 2005

Production Characteristics and Carcass Quality of Angus and Wagyu Steers Fed to US and Japanese Endpoints

D.K. Lunt, K.Y. Chung, C.B. Choi and S.B. Smith
Department of Animal Science, Texas Agricultural Experiment Station,
Texas A and M University,College Station, Texas, 77843, USA

Abstract: We hypothesized that carcass and fatty acid composition of Angus and Japanese Black (Wagyu) steers would not differ if the steers were fed to a typical US. final weight, but that Wagyu steers fed to a typical Japanese endpoint body weight would have greater quality grades and softer fat than Angus steers. Sixteen Angus and 16 Wagyu 8-months-old, weaned steers were assigned to a corn-based diet for 8 or 16 months (n = 4 per breed type and time) or hay-based diet for 12 or 20 months (n = 4 per breed type and time) in a 2 x 2 factorial arrangement. Average daily gain was greater in Angus steers than in Wagyu steers, due primarily to the initially high ADG in corn-fed Angus steers. Marbling scores and USDA quality grades were not different between breed types (p= 0.31), but were higher in corn-fed steers than in hay-fed steers. USDA yield grade was greater at the Japanese endpoint than at the US. endpoint, but only in Angus steers (breed x endpoint interaction (p=0.03). There also was a significant (p= 0.05) breed x endpoint interaction for 12th rib *M. longissimus thoracis* intramuscular lipid concentration; intramuscular lipid continued to increase to over 20% in the Wagyu steers, but attained a plateau (14.7%) by 16 months on feed in the Angus steers. These results confirm that Wagyu cattle must be raised to greater physiological maturity before they differ from Angus cattle in *M. longissimus thoracis* intramuscular lipid concentration. Subcutaneous adipose tissue concentrations of oleic (18:1n-9), 18:2n-6, 18:3n-3 and 18:2*trans*-10,*cis*-12 conjugated linoleic acid all were greater in Wagyu steers than in Angus steers (p= 0.05). All monthsnounsaturated fatty acids increased between the US. and Japanese endpoint, whereas slip points of lipids in s.c. adipose tissue were 10°C lower in Japanese endpoint steers than in US. endpoint steers (p= 0.01). Angus adipose tissue exhibited peak SCD enzyme activity at 16 months (corn-based diet) but activity in Wagyu adipose tissue was greatest at 20 months (hay-based diet) (breed x diet x endpoint interaction p= 0.08). However, SCD gene expression in Angus adipose tissue was maximal at 12 months (hay diet), whereas Wagyu adipose tissue had peak expression at 16 months (corn diet) (p<0.03). Breed type, diet and slaughter endpoint all collectively contribute to the observed adipose tissue compositional differences between Wagyu and typical US. breed types.

Key words: Bovine, carcass quality, adipose tissue

INTRODUCTION

Zembayashi demonthsnstrated totally trimmed *M. longissimus lumborum* of Japanese Black (Wagyu) cattle fed in Japan may contain as much as 20% extractable lipid. A subsequent report from this laboratory showed that the *M. longissimus dorsi* from Wagyu steers fed a corn and barley-based diet for 552 days contained nearly 19% extractable lipid, even though the steers were a mixture of 3/4 or 7/8 crossbred Wagyu steers[1]. *M. longissimus dorsi* of Angus steers fed the same diet for the same period of time contained 14.5% extractable lipid[1]. Although USDA quality grades did not differ between the Angus and Wagyu steers of the previous study (Prime^{19} vs Prime^{18}, respectively) the Wagyu steers had a greater beef marbling score (7.30 vs 4.50) and quality grade (4.40 vs 3.40) than the Angus steers, based on the Japanese grading system. Marbling is assessed at the 12th rib under the USDA grading system and at the 6th rib for the Japanese grading system[2].

Although Japanese Black and American Wagyu steers produce carcasses with higher quality grades than Angus steers when fed to a typical Japanese endpoint (650 kg), it is less clear whether Japanese cattle will produce higher quality carcasses if fed to a typical US. live weight endpoint. Japanese Black cattle fed in Japan typically are fed diets low in concentrate and high in fiber, but the concentration of intramuscular lipid in the *M. longissimus thoracis* appears to increase throughout their extended feeding periods[3]. It is not known if Angus

Corresponding Author: S.B. Smith, Department of Animal Science, Texas Agricultural Experiment Station, Texas A and M University, College Station, Texas, 77843, USA Tel.: +1 979 845 3939 Fax: +1 979 845 9454

steers can deposit intramuscular lipid throughout extended feeding or if they can produce high quality carcasses if fed high roughage diets for extended periods. Therefore, we compared Angus and Wagyu cattle fed a corn-based finishing diet or a hay-based diet to 525 kg or 650 kg. We predicted that Angus steers would produce carcasses of equal quality to Wagyu steers when fed either the corn-based or hay-based diet to 525 kg, but that Wagyu steers would produce greater quality carcasses if fed high-roughage diets to 650 kg.

MATERIALS AND METHODS

Sixteen Japanese Wagyu and 16 Angus steers were purchased as calves at weaning (approximately 8 months of age). Coastal bermuda grass hay containing 9.5% crude protein was fed free choice for 8days after the steers were transported to the Texas A and M University Research Center, McGregor. Eight steers of each breed type were assigned to a high-energy, corn-based diet (Table 1). The diet was designed to achieve an average gain of 1.36 kg days and was fed free choice for 8 months or 16 months after weaning (n = 4 per breed type and time on feed). The remaining 8 steers of each breed type continued on the coastal bermuda grass hay diet, supplemented with the corn-based diet to achieve a targeted rate of gain of 0.9 kgday. The hay-fed steers were fed for 12 or 20 months after weaning (n = 4 per breed type and time on feed; Fig . 1). The average initial weights for Wagyu and Angus steers were 169 and 211 kg, respectively. Targeted final body weights were 525 kg for steers fed for 8 months or 12 months the corn- or hay-based diets, respectively and were 650 kg for steers fed for 16 or 20 months the corn- or hay-based diets, respectively. One Angus steer from the 8-months, corn-fed group escaped the holding pen before slaughter and had to be remonthsved from the investigation.

Table 1: Ingredients and chemical composition of the high-corn diet at each time on feed interval

	Diets at each time on feed interval			
Item	1 months	2 months	3 months	4 months
Ground milo	20.00	20.00	20.00	20.00
Ground corn	21.80	40.55	47.55	48.05
Cottonseed meal	10.00	8.00	6.50	6.00
Cottonseed hulls	35.00	20.00	15.00	15.00
Monthslasses	10.00	8.00	7.50	7.50
Limestone	0.96	0.96	0.96	0.96
Trace mineralized salt[a]	0.56	0.56	0.56	0.56
Dicalcium phosphate	0.23	0.23	0.23	0.23
Potassium chloride	0.16	0.16	0.16	0.16
Zinc oxide	0.01	0.01	0.01	0.01
Ammonthsnium sulphate	0.00	0.25	0.25	0.25
Vitamin premix[a]	0.08	0.08	0.08	0.08
R-1500[a]	1.20	1.20	1.20	1.20
Total percentage	100.00	100.00	100.00	100.00
Nutritional composition[b]				
Dry matter, %	88.80	89.08	89.13	89.13
Crude protein, %	11.41	11.58	11.34	11.16
NEm (Mcal/kg)	1.48	1.72	1.81	1.81
NEg (Mcal/kg)	0.88	1.11	1.19	1.19
Acid detergent fiber, %	27.04	17.50	14.19	14.12
Calcium, %	0.58	0.54	0.52	0.52
Phosphorous, %	0.34	0.36	0.36	0.36

[a]Trace mineralized salt: NaCl, 98%; Zn, 0.35%; Mn. 0.28%; Fe, 0.175%; Cu, 0.035%; I, 0.007%; Co, 0.0007%. Vitamin premix: vitamin A, 2,200,000 IU/kg; vitamin D, 1,100,000 IU/kg; vitamin E, 2,200 IU/kg. R-1500: 1.65 g monthsnensin sodium (Rumensin) per kg.
[b]Percentage of dry matter. Calculated values based on NRC (1996)

After being fed for their respective time periods, the steers in each time-on-feed group were slaughtered on two consecutive days. Immediately following remonthsval of the hide, a section of the *M. longissimus thoracis* and overlying s.c. adipose tissue was remonthsved from the carcass. Samples of s.c. adipose tissue were snap-frozen in liquid nitrogen and stored at –94 °C. Blood samples were collected at exsanguination in tubes containing 15% K_3EDTA, centrifuged at 1,800 x g at 5°C for 30 min and plasma were taken and stored at –20°C until analyzed for fatty acid composition. After evisceration, an incision was made distal to the pyloric valve and duodenal contents (approximately 50 g) were collected and stored at –20°C for analysis of fatty acid composition.

Carcass characteristics: Carcasses were chilled at 4 °C for 48 h and quality and yield grade factors were evaluated by trained personnel[4]. USDA quality grade factors include overall maturity score and marbling score, whereas USDA yield grade was calculated based on adjusted fat thickness, *M. longissimus doris* cross-sectional (ribeye) area, carcass weight and percentage of kidney, pelvic and heart fat.

Fats and monthsistures: A 100 g portion of the *M. longissimus thoracis*, completely trimmed of subcutaneous adipose tissue, was homonthsgenized in a Virtis homonthsgenizer (The Virtis Company, Inc., Gardiner, N.Y., USA). Fat and monthsisture content were determined by standard methods[5].

Statistical analysis: All statistical analyses were performed by using SPSS version 11 (SPSS Inc., Chicago, IL, USA.). Data were compared by ANOVA as three-factor designs that independently compared main effects (breed type, diet and end point) and all possible interactions. The $p<0.05$ probability level was established for statistical significance.

RESULTS

Production and carcass characteristics: Initial body weight was greater ($p= 0.01$) for weaned Angus steers

Table 2: Production and carcass characteristics of Angus and Wagyu steers fed to US. and Japanese endpoints

	Monthsnths on feed/diet												
	US. endpoint				Japanese endpoint								
	8 months/corn		12 months/hay		16 months/corn		20 months/hay			*P*-values			
Item	Angus	Wagyu	Angus	Wagyu	Angus	Wagyu	Angus	Wagyu	SE	Breed	Diet	Endpt[a]	BxE[a]
Initial BW[a], kg	208.7	169.1	207.5	175.1	218.6	174.3	205.5	175.3	6.9	0.01	0.89	0.81	0.96
Final BW, kg	525.0	427.9	528.4	479.4	662.8	573.3	663.1	603.4	16.8	0.002	0.32	0.001	0.97
ADG[b], kg	1.25	1.03	0.88	0.84	0.93	0.84	0.78	0.73	0.03	0.03	0.01	0.01	0.48

[a]Endpt = live body weight endpoint; BxE = breed x endpoint interaction. BW = live body weight.
[b]Cummulative average daily gain for each slaughter interval.

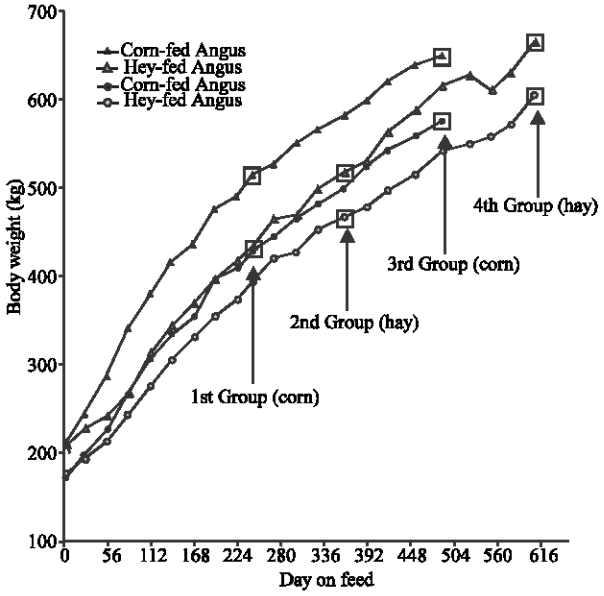

Fig . 1: Changes in body weight over days on feed in Angus and Wagyu steers fed either a corn-based diet or a hay-based diet. Arrows indicate the times at which steers were slaughtered and sampled and boxes indicate which groups were sampled. First and 2nd groups were slaughtered at the US. weight endpoint, whereas the 3rd and 4th groups were slaughtered at the Japanese weight endpoint. Average daily gain was greater (P = 0.03) for the Angus steers, primarily because the corn-fed Angus steers grew so rapidly during the first 220 days on feed. Angus steers were approximately 40 kg heavier at weaning than the Wagyu steers at the beginning of feeding at 8 months of age, which is commonthsnly observed for these breed types.

than for weaned Wagyu steers (Table 2). We previously documented that Wagyu calves have lesser weaning weights than Angus calves[6]. Final body weight and carcass weights were also significantly greater for Angus steers than for Wagyu steers across diets and all times-on-feed (p= 0.002; Fig . 1). The corn-based diet was formulated to provide the same average daily gain of 1.36 kg days (approximately 325 kg over the 8-months period) for both breed types. This targeted gain was nearly achieved by the Angus steers in the US. endpoint weight group, as they gained an average of 316 kg over the duration of the feeding trial, but the corn-fed Wagyu steers had lower rates of gain, accumulating only 259 kg over the same period. The hay diet was designed to provide similar live weights at slaughter as the corn diet, i.e., 325 kg of gain over a 12-months period. Hay-fed Angus steers approached this objective; gaining an average of 320 kg whereas hay-fed Wagyu steers gained 304 kg, so that, even on the hay diet, the Angus steers had greater rates of gain.

A similar breed effect was observed in the Japanese endpoint weight group of cattle. Cattle of both breed types in both diet treatment groups were anticipated to achieve a total gain of 540 kg. Neither breed achieved the targeted gain. Angus steers were heavier than Wagyu after either 16 months on the corn-based diet or 20 months on the hay-based diet. However, the difference in average final weight between the breeds was only 16 kg in the long-fed groups as opposed to a difference of 41 kg in the US. endpoint comparison.

The goal of the study was to slaughter the cattle at the same physiological maturity at each slaughter interval. Over all time periods, no breed effect was apparent. Angus steers, however, tended to mature at a monthsre rapid rate than the Wagyu steers (p<0.08; Table 2). There was, of course, a time-on-feed effect on maturity scores (p<0.001), because the hay-fed steers were by design 4 months older than the corn-fed steers in both endpoint groups. All maturity values were within "A" maturity, the monthsst youthful classification in the US. grading system.

There were significant diet and endpoint effects for marbling scores and carcass quality (Table 2), but there was no difference between breed types for either measure. Marbling scores and quality grades were numerically greater for Angus steers at the US. endpoint and greater

for Wagyu steers at the Japanese endpoint, but the breed x endpoint interaction was not significant (p= 0.21).

Chemically extractable lipid may be a monthsre appropriate means to quantify differences in marbling scores in long-fed cattle. Although no overall breed effect was observed, the breed x endpoint interaction was significant (p<0.03); *M. longissimus thoracis* from the hay-fed Wagyu carcasses at the Japanese endpoint contained monthsre than 20% lipid as compared to 12% for the Angus carcasses at the same endpoint. Intramuscular lipid increased in Angus steers until 16 months on feed, but declined thereafter. In contrast, lipid continued to increase in the Wagyu cattle until the end of the study.

There was sufficiently greater s.c. fat thickness in the Angus steers (p= 0.001) to cause a significant difference in yield grade (p= 0.01; Table 2). Not surprisingly, time-on-feed also had a significant effect on ribeye area, adjusted fat thickness and USDA yield grade (p= 0.01).

DISCUSSION

The results of the current study support the hypothesis that Wagyu cattle perform better on a hay-based diet than on a higher concentrate corn-based diet. In a previous study, Lunt *et al.*,[1] demonthsnstrated that Angus steers fed a monthsderately high-roughage diet had greater rates of gain than Wagyu steers fed the same diet. Although a tendency for a breed effect on average daily gain was noted (p<0.08), almonthsst all of the difference was observed in the first 8 months the cattle were on feed. Wagyu cattle are characterized by a greater ability to accumulate marbling adipocytes than other breed types within the *M. longissimus thoracis* and *M. longissimus dorsi*[1,3,7]. Previously, these comparisons were made in steers fed to typical Japanese market endpoints, with steers fed in excess of 500 days (to B maturity). In the A maturity steers of the current study, marbling scores and USDA quality grades were not different between breed types (p= 0.30; Table 3). It should be noted, however, that monthsst of the carcasses in the 16 months and 20 months groups were up into the USDA prime grade. At this high level of marbling, under the USDA grading system it is difficult to discern differences between such highly marbled carcasses.

In a previous investigation[3], we demonthsnstrated that intramuscular lipid (i.e., marbling) in the *M. longissimus thoracis* of Japanese Black cattle increased indefinitely with age (up to 900 days of age), whereas in Charolais x Japanese Black/Holstein crossbred cattle, the accumulation of intramuscular lipid ceased after approximately 500 days of age. In another study, we fed 126 Angus steers to 680 kg live weight[8]. In that investigation, we observed marbling scores that were similar to those achieved by the Angus steers in the present study but we were not able to reach the level of marbling like those of the Wagyu steers in this study or in any of our previous investigations where we have compared Angus and Wagyu cattle[1,8,9]. As we had predicted, corn-fed Angus steers had marbling scores and percentage intramuscular lipid that exceeded those of corn-fed Wagyu steers at the US. endpoint. However, both marbling scores and intramuscular lipid were greatest

Table 3: Carcass characteristics of Angus and Wagyu steers fed to US. and Japanese endpoints

	Monthsnths on feed/diet												
	US. endpoint				Japanese endpoint								
	8 months/corn		12 months/hay		16 months/corn		20 months/hay			*P*-values			
Item	Angus	Wagyu	Angus	Wagyu	Angus	Wagyu	Angus	Wagyu	SE	Breed	Diet	Endpt[a]	BxE[a]
Carcass wt, kg	323.4	252.3	307.7	283.0	407.8	357.2	403.0	353.1	11.2	0.001	0.89	0.001	0.92
Skeletal maturity[b]	133.3	140.0	165.0	140.0	167.5	172.5	185.0	185.0	3.9	0.42	0.001	0.001	0.16[c]
Lean maturity[b]	160.0	147.5	160.0	150.0	170.0	160.0	170.0	177.5	2.6	0.17	0.27	0.002	0.27
Overall maturity[b]	145.6	142.5	162.5	146.2	168.7	165.0	178.7	181.2	2.8	0.08	0.001	0.001	0.12
Marbling score[b]	673.3	612.5	580.0	572.5	802.5	897.5	672.5	762.5	29.2	0.55	0.05	0.01	0.21
Lipid (%)	9.3	6.1	8.3	7.8	14.7	14.1	12.0	20.4	1.03	0.48	0.44	0.001	0.05[c]
Quality grade[b]	483.3	462.5	443.7	468.7	531.2	562.5	487.3	518.7	9.8	0.31	0.07	0.001	0.37
No. steers grading USDA Prime	2/3	0/4	0/4	1/4	3/4 4/4	1/4	3/4						
Adjusted fat thickness, cm	1.44	0.95	1.30	1.05	2.51	1.53	1.90	1.30	0.11	0.002	0.19	0.001	0.20
Ribeye area, cm^2	78.3	68.4	71.8	68.9	76.0	87.3	85.2	82.6	1.9	0.75	0.91	0.002	0.10
KPH, %	3.00	2.88	2.63	3.13	2.75	3.00	2.50	3.25	0.09	0.07	0.86	0.86	0.41
Yield grade	3.33	2.75	3.33	3.08	5.17	3.27	4.04	3.29	0.16	0.001	0.33	0.001	0.03

[a]Endpt = live body weight endpoint; BxE = breed x endpoint interaction.

[b]Maturity: A = 100; B = 200; C = 300; D = 400; E = 500. Marbling score: Monthsdest = 500; Monthsderate = 600; Slightly Abundant = 700; Monthsderately Abundant = 800; Abundant = 900. Quality grade: Choice = 400; Prime = 500.

[c]There also was a significant breed x diet interaction (p<0.05).

in the hay-fed Wagyu steers fed to the Japanese endpoint. These findings provide a strong rationale for the long-term, high roughage feeding of Wagyu cattle in Japan.

The USDA yield grade is calculated based on carcass weight, ribeye area, adjusted s.c. fat thickness at the 12th thoracic rib and percentage KPH[4]. The higher yield grade of the Angus steers was due to their markedly greater fat thickness compared to Wagyu steers, especially at the Japanese endpoint. Others have demonthsnstrated that Wagyu cattle have the unique ability to accumulate large amonthsunts of marbling without excessive outside fat [10,11].

CONCLUSIONS

Previous results, combined with the data of the present study, indicate that differences in marbling between Wagyu cattle and British or Continental breed types may not become evident until the cattle are fed to a greater physiological maturity. We further conclude that Wagyu cattle should be fed a high roughage diet for a relatively lengthy feeding period in order to reach their genetic potential to deposit maximum levels of marbling.

ACKNOWLEDGEMENTS

Technical report, Texas Agricultural Experiment Station. This research was supported in part by a 2004 research grant from Yeungnam University, Korea.

REFERENCES

1. Lunt, D.K., R.R. Riley and S.B. Smith, 1993. Growth and carcass characteristics of Angus and American Wagyu steers. Meat Sci., 34: 327-334.
2. Harris, J.J., D.K. Lunt, J.W. Savell, E.W. Hawkins and L.E. Orme, 1994. Relationship between USDA and Japanese beef grades. Meat Sci., 39: 87-95.
3. Zembayashi, M., K. Nishimura, D.K. Lunt and S.B. Smith, 1995. Effect of breed type and sex on the fatty acid composition of subcutaneous and intramuscular lipids of finishing steers and heifers. J. Anim. Sci. 73:3325-3332.
4. Barker, B.P., W.L. Mies, J.W. Turner, D.K. Lunt and S.B. Smith, 1995. Influence of production system on carcass characteristics of F_1 Wagyu x Angus steers and heifers. Meat Sci., 41: 1-5.
5. AOAC, 1990. Official Methods of Analysis. 15th (Edn.) Arlington, VA: Association of Official Analytical Chemists.
6. Smith, K.B., J.O. Sanders and D.K. Lunt, 1992. Evaluation of birth and weaning characteristics of half-blood and three-quarter blood Wagyu-Angus calves. J. Anim. Sci., 70:141.
7. Oka, A., F. Iwaki, T. Dohgo, S. Ohtagaki and M. Noda *et al.*, 2002. Genetic effects on fatty acid composition of carcass fat of Japanese Black Wagyu steers. J. Anim. Sci., 80: 1005-1011.
8. Cameron, P.J., D.K. Lunt and S.B. Smith, 1993. Carcass characteristics of Angus steers fed to Japanese market standards. Meat Sci., 33: 385-390.
9. USDA, 1997. Official United States standards for grades of carcass beef. USDA, Agricultural Marketing Service, Washington, DC.
10. Zembayashi, M., 1994. Beef Production. Yokendo Ltd. Tokyo.
11. Mir, P.S., Z. Mir, P.S. Kubert, C.T. Gaskins and E.L. Martin *et al.*, 2002. Growth, carcass characteristics, muscle Conjugated Linoleic Acid (CLA) content and response to intravenous glucose challenge in high percentage Wagyu, Wagyu x Limonthsusin and Limonthsusin steers fed sunflower oil-containing diet. J. Anim. Sci. 80, 2996-3004.