GROWTH PERFORMANCE, CARCASS CHARACTERISTICS AND TENDERNESS OF MEAT FROM BEEF CATTLE WITH WAGYU GENETIC INFLUENCE

P. S. Mir*[1], D. R. C. Bailey[2], Z. Mir[1], S. D. M. Jones[1], R. J. Weselake[3], F. J. Lozeman,[4]
Agriculture and Agri-Food Canada, [1]Lethbridge, AB., [2]Charolettetown, PEI [3]University of Lethbridge, Lethbridge AB. and [4]Lozeman Family Farms, Claresholm, AB.

INTRODUCTION

Canada is a major beef exporting country. In excess of 50% of the beef produced is exported either to the United States of America or to growing markets in Pacific Rim countries. Consumers in these countries prefer highly marbled beef compared to those in Canada. The price differential for beef that has "abundant marbling" relative to that with less marbling can be substantial thus there is interest in improving this trait in beef cattle. Currently, less than two percent of carcasses produced in North America grade "Prime" (which is equivalent to having "slightly abundant marbling") and approximately 27 % of carcasses grade "Choice" by US standards or "AAA" by the Canadian grading system which is equivalent to having a "small" amount of marbling. These grades are based on visual assessment of the extent of marbling fat present in muscle. In the USA and Canada a higher price is paid for carcasses with more marbling than for those with less marbling with the price differential being greater in the US for carcasses that grade "US-Choice" as opposed to "US-Select" (Gaskins et al. 1995). However, cattle have to be fed for long durations on expensive feed for the carcasses to grade 'Choice'. In many instances animals fed high energy diets for extended durations, to have adequate marbling also have greater overall adiposity, consequently the proportion of lean meat declines.

It is known that animals with the Japanese Wagyu genetics marble substantially (Lunt et al. 1993). These are typically low birth weight cattle and have lower live weight when compared with crossbred beef cattle at similar age. In Japan, Wagyu cattle are in excess of 36 months of age at time of slaughter, unlike cattle in North America which are 15 to 18 months of age at slaughter. In Japan, Wagyu cattle are backgrounded for long durations to achieve heavy carcasses (415 kg) and to maximize meat yield. In Canada however, in order that carcasses do not exceed 340 kg or 750 lb, fast growing, late and heavy maturing crossbred cattle are backgrounded for a short period of time and finished with high grain diets at young ages and at live weights of 570 kg. In an attempt to achieve acceptable carcass weight, marbling grade and improved growth performance, by Canadian standards, experiments were conducted to determine whether the inclusion of Wagyu genetics into beef cattle would provide cattle with both, faster growth rate and high marbling potential. In order to determine the influence of Wagyu genetics on growth performance cattle were generated by inseminating Angus or 50% Wagyu dams (Wagyu X Angus or Wagyu X Continental composite) with Wagyu semen, to obtain either 50 or 75% Wagyu cattle for use in the investigations.

Since we had cattle with the two levels of Wagyu genetic influence another experiment was conducted to determine whether other biochemical parameters in live animals were associated with the physiology of marbling. Smith and Crouse (1984) demonstrated in laboratory studies that glucose was the preferred substrate for fat synthesis in muscle fat cells, while acetate was the substrate in the subcutaneous adipose tissue. The maintenance of blood glucose concentrations is by the hormone insulin. Therefore, we were interested in determining the effect of fasting and challenge with intravenous glucose on blood glucose and insulin concentrations in beef cattle.

In the studies conducted, the Wagyu crossbred cattle were backgrounded and finished with diets commonly used in our feedlots and the growth performance, carcass characteristics and meat quality were compared to those of crossbred steers commonly used in Canadian feedlots. When the age of the cattle was approximately 350 days the intravenous glucose tolerance test was conducted in 18 steers, with six from each type of cattle, and the response of the cattle to intravenous glucose was determined.

Spring born calves with 0% Wagyu influence (six, continental crossbred steers), 50% Wagyu influence (24 heifers and 16 steers 50/50 Wagyu/Angus crossbreds) and 75% Wagyu influence (15 heifers and 12 steers containing 25% from Angus or other European breeds) were obtained from the Agriculture and Agri-Food Canada Substation at Onefour and from the Lethbridge Research Station at weaning and placed in the Individual Feeding Barn at Lethbridge. Calves were provided with a totally mixed backgrounding diet containing 35% barley grain and 65% barley silage containing a beef vitamin mineral premix. Cattle were fed the backgrounding diet until they weighed 400 kg, after which they were adapted to a finishing diet consisting of 80%

barley and 20% barley silage on dry matter basis, with vitamin/ mineral premix (Mir et al. 1997). Cattle were weighed every four weeks and back fat depth was measured by ultra-sonagraphy every eight weeks. During the backgrounding phase cattle within each percentage of Wagyu were maintained on the backgrounding diet until all cattle in that percentage were 400 kg after which they were adapted to a finishing diet. During the finishing phase animals were selected for shipment when their back fat was greater than 8 mm on a back fat measurement day (every eight weeks). Information regarding average daily gain (ADG), dry matter intake (DMI), feed conversion efficiency (FE) and days on feed were obtained.

When cattle were approximately 350 days of age the intravenous glucose tolerance test was conducted in six steers from each group of cattle (0, 50 and 75 % Wagyu) by the procedure outlined by Wastney et al. (1982). Cattle were fasted for 24 hours and blood samples were collected prior to and for 120 min after intravenous glucose infusion. The glucose was infused as a 50% glucose solution (in 0.9% saline) at 0.3% of body weight. Glucose and insulin concentrations were determined.

Cattle were processed and carcasses were graded by Agriculture and Agri-Food Canada trained graders the day after slaughter. The carcass characteristics evaluated include, warm carcass weight, warm carcass yield per unit live weight, lean meat yield, fat grade and marbling (Newman et al. 1994). After grading, a three rib section was obtained from all of the steers with 0 % Wagyu influence and from animals from both sexes with 50 and 75% Wagyu influence. The rib section was analysed for meat quality by determining meat colour, drip loss, final pH after aging the meat at 2° C for a ten days and Warner-Bratzler shear force by taking a 19 mm diameter core. The meat was prepared for measurement of Warner-Bratzler shear force by heating a 2.54 cm thick steak in an air tight tin containing physiological saline to an internal temperature of 72° C. Following which the tin was immediately cooled and the shear force measured by taking three cores. The moisture and solvent extractable fat content of the meat was determined.

Data for all parameters were analysed by the General Linear Models Procedure (SAS 1995) for variance using as a completely randomised factorial designed experiment with breed type and sex being the two factors. Differences among cattle with 0, 50 and 75 % Wagyu influence and sexes were evaluated by the least square means procedure. Carcass data were analysed with backfat as covariate.

GROWTH PERFORMANCE

The weaning weight, or weight at the beginning of the trial, of Continental crosses, 50 and 75 % Wagyu were observed to be in three categories and different from each other (Table 1). However, differences in initial weight between steers and heifers within each level of Wagyu influence were not present. Rate of gain (ADG) through the backgrounding phase of Continental crosses and 50% steers was similar. While ADG of heifers and 75% Wagyu steers was lower than that of the Continental crosses. Since the Wagyu cattle were smaller at weaning the days on feed were longer than for the Continental crosses to arrive at the target weight (400 kg) prior to being switched to finishing diets.

However, during the finishing phase the Continental crosses gained more rapidly than all the Wagyu crossbred cattle and final weights of 50 % Wagyu heifers and 75% Wagyu cattle were lower than the expected target weight of 500 kg (Table 2). Even though the intakes of the 50 and 75% Wagyu cattle were lower than of the Continental crosses the feed conversion efficiency was inferior relative to that of the Continental crosses.

CARCASS CHARACTERISTICS

The 50 and 75% Wagyu cattle required longer durations of feeding, thus the age at slaughter for these cattle was greater than for the Continental crosses (Table 3). These cattle were finished at the average age of 441 days with acceptable carcass characteristics which is generally observed in Canadian feedlots. The 50 % Wagyu steers were on feed for a relatively, shorter period than the heifers and thus the age at slaughter was less than of the heifers and 75% Wagyu steers. Warm carcass weight was similar for the Continental crosses and 50% Wagyu steers and greater than of the heifers and the 75% Wagyu steers. These results indicate that steers with 50% Wagyu can be finished with barley based diets to produce an acceptable carcass within 17 mo. with no differences in lean meat yield.

When the marbling score was determined (Table 4), 60 of 65 carcasses from Wagyu crossbred cattle graded, "Canada AAA," and contained more than a "small" amount of intramuscular fat.

Twenty of these carcasses graded what is considered as "Canada Prime - AAAA" and this grade is equivalent to the "Prime" grade in the USA, while only two of the six continental crossbred cattle graded "Canada AAA." The fat content of the meat reflects the marbling grade awarded to the carcasses. Similarly in earlier work (Mir et al. 1997) we observed that 83 % of the carcasses from 75% Wagyu cattle graded 'AAA'in comparison to 13% of carcasses from crossbred cattle without Wagyu genetics.

Meat from all treatment groups had low Warner-Bratzler shear forces and mean values ranged from 3.8 to 4.5 kg when a 19 mm. core was extracted. This value is comparable to those reported by Huffman et al. (1996) for extremely tender meat.

INTRAVENOUS GLUCOSE TOLERANCE TEST (IVGTT)

Fasted plasma glucose concentrations were similar ($P > 0.05$) for all steers and ranged between 4.5 and 6.7 mM (Figure 1A). Differences in plasma glucose concentrations after glucose infusion were not observed among steers with different percentages of Wagyu genetic influence. Despite the similarity in glucose response in all three types of steers, differences in the insulin responses were observed to glucose challenge under the conditions of the experiment (Figure 1B). Plasma insulin concentrations prior to glucose challenge, and 5 and 10 min after infusion were higher ($P < 0.05$) for the 0 % Wagyu steers than for either 50 or 75 % Wagyu steers. Differences were not observed ($P > 0.05$) among the three types of cattle, for the parameters: time to attain maximum insulin concentration (31.7 ± 7.8 min), area under the insulin response curve (851 ± 148 mm^2) and rate of increase in insulin concentration (RIIC; 0.352 ± 0.079 ng ml^{-1} min^{-1}).

Plasma insulin concentrations prior to infusion were not correlated with chemical fat in the *Longissimus thoracis*. This differs from the positive correlation between insulin concentrations and muscle fat by Trenkle and Topel (1978). However, insulin concentrations 20 min ($r = 0.51$, $P = 0.103$, $n = 11$), 30 min ($r = 0.60$, $P = 0.05$, $n = 11$) and 35 min ($r = 0.57$, $P = 0.07$, $n = 11$) after glucose infusion tended to be positively correlated to chemical fat content of the muscle. Muscle chemical fat content and RIIC were also correlated ($r = 0.63$, $P = 0.04$, $n = 11$). A negative trend was observed for the correlation between marbling score and insulin concentrations at 20 min after glucose infusion ($r = -0.47$, $P = 0.09$, $n = 15$).

Even though differences in plasma glucose concentrations were not noted for the three types of steers, plasma glucose concentrations from 15 to 120 min post glucose infusion either tended ($P < 0.1$) to be, or were significantly correlated with marbling score, with the coefficient being greatest for glucose concentration in samples obtained 90 min after glucose infusion (G90; $r = 0.71$, $P = 0.005$, n=15). Similarly, glucose concentrations from 60 to 120 min post glucose infusion were correlated ($P < 0.05$) to chemical fat content of *Longissimus thoracis* muscle with the coefficient being greatest for the G90 ($r = -0.77$, $P = 0.006$, $n = 11$). Regression analysis for the dependent variables marbling score and fat content of *Longissimus thoracis* muscle, indicated that the equations were:

Marbling score = -2.2439 ($\pm$ 1.917)+ 0.8122 G90 ($\pm$ 0.234);

$r^2 = 0.5013$, $P = 0.0046$, $n = 15$

Fat content of *Longissimus thoracis* = 449 ($\pm$ 84)- 37.6 G90 ($\pm$ 9.2)+ 199 RIIC ($\pm$ 66.1),

$R^2 = 0.806$, $P = 0.0014$, $n = 11$

Conclusion

Wagyu genetic influence enhanced marbling potential in beef cattle, however a concomitant decline in growth rate, especially during the finishing phase, and carcass size was observed. All animals were finished within 17 mo on a barley based diet. Performance of 50% Wagyu steers appeared to be comparable to that of continental crossbred steers for growth rate and carcass characteristics but the extent of marbling was significantly greater than for the continental crossbred steers. The results from the IVGTT indicated that factors involved in glucose management in the body to be associated with marbling potential.

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Table 1. Least square means for performance characteristics of cattle 0, 50 and 75 % Wagyu genetic influence: backgrounding phase.

Type of cattle % Wagyu	n	In. Wt. (kg)	F Wt. (kg)	ADG (kg)	DOF	DMI (kg)	FE
0-Steers (S)	6	264 a	409 b	1.03 a	140 c	8.2 a	8.0
50-S	16	225 b	457 a	1.03 a	224 b	7.8 a	7.6
50-Heifers (H)	24	215 b	424 ab	.90 b	234 b	7.3 b	8.2
75-S	12	184 c	410 b	.95 ab	240 ab	7.1 b	7.6
75-H	15	179 c	402 b	.88 b	253 a	6.9 b	7.9
SEM		6.8	8.8	.02	5.5	.19	.21

n - number of animals in each group, In.Wt - Initial or weaning weight, F. Wt- Final weight, ADG- Average Daily Gain, DOF - Days on feed, DMI - Dry matter intake, FE - Feed Efficiency (DMI / ADG).
a - c - Means denoted by a different letter in a column are different ($P < 0.05$).
0% Wagyu influence (continental crossbred steers), 50% Wagyu influence (50/50 Wagyu/Angus crossbreds) and 75% Wagyu influence (25% from other European breeds)

Table 2. Least square means for performance characteristics of cattle with 0, 50 and 75 % Wagyu genetic influence: finishing phase.

Type of cattle % Wagyu	F Wt. (kg)	ADG (kg)	DOF	DMI (kg)	FE
0-Steers (S)	516 a	1.48 a	78 ab	10.3 a	7.3 a
50-S	530 a	0.85 b	84 ab	7.9 b	9.9 b
50-Heifers (H)	499 a	0.85 b	87 a	7.5 b	9.1 ab
75-S	470 b	0.78 b	77 ab	7.3 b	9.6 ab
75-H	457 b	0.80 b	69 b	7.3 b	10.0 b
SEM	10.2	0.06	4.4	28	.65

F. Wt- Final weight, ADG- Average Daily Gain, DOF - Days on feed, DMI - Dry matter intake, FE - Feed Efficiency (DMI / ADG).
a - c - Means denoted by a different letter in a column are different ($P < 0.05$)
0% Wagyu influence (continental crossbred steers), 50% Wagyu influence (50/50 Wagyu/Angus crossbreds) and 75% Wagyu influence (25% from other European breeds)

Table 3. Least square means for carcass characteristics of cattle with 0, 50 and 75 % Wagyu genetic influence.

Type of cattle % Wagyu	Age (d) at slaughter	DOF	Carcass weight (kg)	Dressing percentage (%)	Lean meat yield (%)
0-Steers (S)	441 d	218 c	292 a	60.5 a	55.9
50-S	510 c	308 b	295 a	58.1 b	55.0
50-Heifers (H)	524 b	322 a	279 b	58.2 b	54.3
75-S	541 a	318 ab	259 b	58.5 b	54.1
75-H	546 a	323 a	252 b	57.3 b	54.4
SEM	4.2	3.8	6.7	.44	.54

DOF - Days on feed,
a - c - Means denoted by a different letter in a column are different ($P < 0.05$).
0% Wagyu influence (continental crossbred steers), 50% Wagyu influence (50/50 Wagyu/Angus crossbreds) and 75% Wagyu influence (25% from other European breeds)

Table 4. Least square means for carcass quality and shear force of carcasses from cattle with 0, 50 and 75 % Wagyu genetic influence.

Type of cattle % Wagyu	Rib eye area (cm^2)	Backfat (mm)	Marbling score	Moisture (%)	Shear force (kg)	Fat (On dry basis %)
0-Steers (S)	82	7.7 d	7.8 a	71.9 a	4.3	15.6 b
50-S	78	16.0 b	6.0 b	71.1 a	4.5	26.6 a
50-Heifers (H)	77	18.7 a	5.1 bc	70.3 ab	3.8	29.6 a
75-S	73	11.3 c	5.7 b	70.5 a	4.0	25.0 a
75-H	76	11.3 c	4.0 c	68.3 b	3.9	30.8 a
SEM	2.4	.86	.39	.70	.19	.86

a - c - Means denoted by a different letter in a column are different ($P < 0.05$).
0% Wagyu influence (continental crossbred steers), 50% Wagyu influence (50/50 Wagyu/Angus crossbreds) and 75% Wagyu influence (25% from other European breeds)
Marbling score was on an inverse scale with 10 indicating devoid of marbling and 1 indicating abundant marbling.

Figure 1. Mean (± SE) plasma glucose(A) and insulin (B) concentration during intravenous glucose tolerance tests in 0% Wagyu (con), 50% Wagyu (50W) and 75% Wagyu (75W) steers