PERFORMANCE AND CARCASS TRAITS OF EARLY WEANED STEERS RECEIVING EITHER A PASTURE GROWING PERIOD OR A FINISHING RATION AT WEANING

S. E. Myers, D. B. Faulkner, T. G. Nash, L. L. Berger, D. F. Parrett, and F. K. McKeith

SUMMARY

A 2-yr study was conducted to evaluate 1) steers fed ad libitum high concentrate after weaning (CONC), or 2) steers grown on pasture for 82 d, followed by high concentrate finishing (PAST) on the performance and carcass traits of 74 early weaned (117 d of age) steers. Potential breed differences were evaluated using steers of three different breed types: 1) ¾ Angus x ¼ Simmental (BRI), 2) ¾ Simmental x ¼ Angus (CON), and 3) ½ Wagyu x ¼ Angus x ¼ Simmental (WAG) crossbred. Steers were randomly assigned within breed to the two treatments. There was no interactions (P > .10), so the data were pooled over years. The CONC steers had .17 kg/d higher ADG (P = .0001), 1.09 kg/d lower intake (P = .0001), and .013 units better gain:feed (.190 vs .177, P = .008) than PAST steers overall. Growing treatment did not affect total concentrate consumed (P = .97). The BRI steers required 31 fewer d than CON steers (P = .008), and 23 fewer d than WAG steers (P = .05) when fed to a constant fat endpoint (1.1 cm). The BRI steers exhibited .16 kg/d higher ADG (P = .0003), tended (P = .07) to have .49 kg/d higher intake, and exhibited .01 units better gain:feed (.189 vs 180) than WAG steers. When compared to CON steers, BRI steers consumed 310 kg less total concentrate (P = .0003). No differences (P > .38) were observed between growing treatments for carcass characteristics or sensory attributes except, CONC steers tended (P = .11) to improve percentage of steers grading Average Choice or higher by 47% over PAST steers. The WAG steers had a 76 unit higher marbling score (1,000 = Small^{00}, 1,100 = Modest^{00})(P = .006) than BRI steers resulting in 19% more (P = .09) steers grading ^{3} to Choice, and 82% more (P = .03) grading ≥ to Average Choice. Liver (P = .15) and rumen (P = .01) weights as a percentage of hot carcass weight were reduced for CONC steers. The CONC steers had higher gain, lower intake, better efficiency, reduced liver and rumen weights, and consumed the same amount of total concentrate when compared to PAST steers. The BRI steers had less finishing days and lower daily intake compared to CON steers. The WAG steers had more days finishing, lower gain, lower intake, more undesirable efficiencies, consumed the same amount of total concentrate, and improved quality grades compared to BRI steers.

INTRODUCTION

Economic pressures to improve production efficiency have prompted the beef cattle industry and researchers to evaluate the performance of different biological types of cattle and methods to produce cattle that result in higher quality grade. Feeding grain diets to cattle is generally considered to result in meat that is more tender, flavorful, and juicy than forage-fed cattle.

Early weaning systems have been utilized when available feed is of poor quality, when grazing forages with a short growing season, when cows are milking poorly, when calves are nursing first calf heifers, during periods of drought, when there is a feed shortage, or in late calving herds. Robison et al. (1978) and Bartle et al. (1984) concluded that, after 2 to 4 mo of lactation, cows were producing insufficient milk to meet the calves energy requirements.

Some researchers have reported that composition of carcasses is similar whether cattle are fed a grain-based diet immediately after weaning or after a period of slower growth (Ridenour et al., 1982). Other investigators have indicated, however, that nutrition impacts carcass composition (Dikeman et al., 1985a).

A great deal of interest currently exists in beef eating quality. Tenderness is generally regarded as the most important sensory characteristic affecting palatability of beef, although juiciness and flavor are also important. Tenderness differences in beef are likely associated with a number of factors such as: amount of intramuscular fat, sarcomere length, collagen content, size and type of muscle fibers, and enzymatic activity involved in postmortem aging (Whipple et al., 1990). Cover et al. (1956) and Palmer et al. (1958) found a low correlation between marbling and tenderness.

Altering feed intake and protein concentration in the diet may alter visceral organ mass. Changes in visceral organ mass may then change the energy and protein available for gain and efficiency of gain. Tissues of the viscera, namely liver and gut, have been estimated to account for 40 to 50% of total body heat production (Webster, 1981) and compose only 6 to 10% of body weight (Burrin et al., 1990). Studies have demonstrated that changes in maintenance energy requirements are closely correlated to size of metabolically active visceral organs (Koong et al., 1982; Ferrell and Koong, 1986). The objectives of the present study were to determine the effects of feeding a high concentrate diet to steers after weaning versus a growing period on pasture and then a high concentrate diet on performance, carcass and meat quality, and evaluation of three breed types in these two production systems.

MATERIALS AND METHODS

Steers and Diets. The 2-yr experiment was conducted at the University of Illinois Beef Research Unit in Urbana. The first year the trial was conducted from June 29, 1995 through June 13, 1996 and the second year from June 19, 1996 through June 27, 1997. A total of 74 spring born (January-April) steers calves were early weaned (117 ± 23 d) and fed a high energy diet prior to trial initiation. Steers were randomly assigned within breed type to one of two treatments where the steers were: 1) fed ad libitum high concentrate after weaning (CONC), or 2) grown on pasture for 82 d, followed by high concentrate finishing (PAST). Twenty-six ¾ Angus x ¼ Simmental (BRI, 140 ± 34 kg), 24 ¾ Simmental x ¼ Angus (CON, 158 ± 18 kg), and 24 ½ Wagyu x ¼ Angus x ¼ Simmental (WAG, 142 ± 28 kg) crossbred steers were utilized to evaluate potential breed type differences. The steers used in this study were from at least eight different sires of each breed type.

In yr 1, steers were ear-tagged with Cutter Blue insecticide tags (Miles, Shawnee Mission, KS), treated for parasites with Ivomec® (Merck, Rahway, NJ), and vaccinated with One Shot®, Ultrabac 7/Somubac®, Bov Eye® (Smith Kline Beecham, West Chester, PA), Fermicon 7/Somnugen (Bio-Ceutic, St. Joseph, MO), Pyramid MLV 4 (Fort Dodge, Fort Dodge, IA), and Vision® 7 Somnus (Bayer Corporation, Shawnee Mission, KS) at weaning. Steers then received boosters of the same vaccinations 2 wk later. In yr 2, the steers were vaccinated with One Shot®, Bovi Shield 4®, Bov Eye® (Smith Kline Beecham), and Vision® 7 Somnus (Bayer Corporation) at weaning. Steers then received boosters of the same vaccinations 3 wk later. In yr 2, following the 82 d growing period, steers were given TSV-2, Cattle Master IBR PI_3 BRSV (Smith Kline Beecham), and were treated for parasites with Ivomec® (Merck).

At 127-d of age, steers were assigned to their respective treatment, weighed, measured at the hip, and implanted with Synovex®-C (100 mg of progesterone and 10 mg of estradiol benzoate; Syntex, Palo Alto, CA). The CONC steers were separated into two pens and were allowed an adjustment period of 28 d during which the corn level was gradually increased to 77%. Diet composition is shown in Tables 1 and 2. The PAST steers were rotated three times on endophyte infected tall fescue (*Festuca arundinacea* Schreb.), Smooth bromegrass (*Bromus inermis* Leyss.), and orchardgrass (*Dactylis glomerata* L.) pastures through d 127 to 208. Those steers were also supplemented with .91 kg of cracked corn per head daily. All individual calf weights were taken without withdrawal from feed and water.

At 208 d of age, steers were weighed, measured at the hip, and implanted with Synovex®-S (200 mg of progesterone and 20 mg of estradiol benzate; Syntex, Palo Alto, CA). The PAST steers were separated into two pens and were allowed an adjustment period of 28 d in which the corn level of the finishing ration was gradually increased to 77%. From this point until the end of the trial both treatments were fed the same diet. Steers were finished in an open sided barn on solid-floor pens. Pens were bedded and were equipped with automatic waterers. Steers were implanted with Synovex®-S (200 mg of progesterone and 20 mg of estradiol benzate; Syntex) on d 292 of the trial.

Pinpointer 4000B (UIS Corp., Cookeville, TN) feeding devices or "imitation" pinpointer feeding devices were used to measure individual feed intakes (DeHaan et al., 1990). The "imitation" feeders had the same dimensions as the pinpointer feeders, allowing only one steer to eat at any one time, but did not possess the electronic scales. Steers were rotated between the two types of feeders at 2-wk intervals. Individual feed intakes were recorded using the pinpointer feeders, and pen feed intakes were recorded from the "imitation" feeders during the 2-wk periods. Individual feed intakes from "imitation" feeders were then estimated by calculating the individual's percentage intake of pen intake from pinpointer feeders. This percentage was then multiplied by pen intake from "imitation" feeders (DeHaan et al., 1990).

Steer backfat was monitored by ultrasound. Steers were slaughtered at a constant fat endpoint (1.1 cm ± .33 actual). Final weights and hip heights were taken. Harvest weight was determined by dividing hot carcass weight by .61. No differences in dressing percent were observed due to treatment ($P > .05$). The weights from d 127, 208, and 413 were used to calculate the performance of steers during those time periods. Average daily gain and efficiency (gain/feed) were calculated.

Steers were processed at the University of Illinois Meats Laboratory. Hot carcass weights were obtained from all steers at the time slaughter. After the carcasses were chilled for 24 h, the following measurements were obtained by trained University of Illinois personnel: 1) longissimus muscle area (LMA) taken by direct grid reading of the longissimus at the 12th rib, 2) subcutaneous fat over the longissimus muscle at the 12th rib (subjectively adjusted for unusual fat distribution), 3) kidney, pelvic, and heart fat estimated as a percentage of carcass weight, and 4) marbling score (USDA, 1975). Carcass measurements were used to calculate yield and quality grades.

Meat Quality Measurements. Meat quality assessments were made by removing the 9-10-11 rib cut from the left side of each carcass according to the procedure of Hankins and Howe (1946). All removed sections were collected and frozen (-20°C) and stored until all steers from that respective year had been processed. The remaining portion of the longissimus (12th rib area) was vacuum-packaged, and aged at 4°C until 14 d postmortem, then frozen at -20°C until shear force and sensory evaluation could be completed. The 9-10-11 rib cut portions were thawed at 4°C and deboned. Weights of the bones, and lean and fat tissue were recorded. The fat and lean tissue was then ground in a bowl mixer. Subsamples were taken and frozen (-20°C) for subsequent chemical analysis. Samples were used to determine the percentage of protein, fat, and moisture contents.

Proximate analysis procedures for fat and water contents were conducted on the 9-10-11 rib subsamples using the procedures described by Novakofski et al. (1989). All samples were oven dried (110°C for 24 to 48 h). Fat was extracted using an azaeotropic mixture of warm chloroform and methanol (4:1). Two samples of every 9-10-11 rib subsample were also assayed for protein using a Kjeldahl procedure (AOAC, 1992).

Two steaks, 2.5 cm thick, from the ribeye roll were cut with a band saw for shear force and sensory evaluation. Steaks were individually wrapped in paper and frozen at -20°C until the analyses could be completed. Steaks for shear force determination were thawed for 24 h at 4°C and then cooked on a Farberware open-hearth grill (model 155N, Walter Kidde, Bronx, NY) to an internal temperature of 70°C. Temperature was monitored using copper Constantan thermocouples and a recording thermometer (Campbell Scientific, Logan, UT). Steaks were weighed before and after cooking to determine cooking loss. Steaks were cooled to 25°C and six 1.3-cm diameter cores were removed parallel to the meat fibers. Shearing was accomplished with an Instron model 1122 Universal Testing Machine (Instron, Cantaon, MA) fitted with a Warner-Bratzler shear attachment. The full scale load was set at 10 kg, and the chart drive and crosshead speeds were 200 mm/min. Shear force steaks were cooked, cored, and sheared the same day. Mean shear force was calculated from the six cores.

Steaks for sensory evaluations were prepared and cooked using the same procedures as for shear force. Six panelists consisting of faculty and graduate students at the Meat Science Laboratory were trained according to the procedures for sensory evaluation described by the American Meat Science Association (1978). Panelists evaluated juiciness, tenderness, and off-flavor intensity using a 15-cm structured line scale with anchors and a midpoint (0 cm = extremely dry, tough, and intense off-flavor to 15 cm = extremely moist, tender, and no off-flavor). Water was provided to panelists to cleanse the palate. Each judge scored the meat samples while in the confines of an individual booth that was illuminated with red light. Order of taste panel steaks was at random, and each treatment and breed was represented once each tasting session (five total each yr).

Visceral Measurements. To compare visceral organ mass between treatments, weights of visceral tissues were obtained on the CON steers in yr 2 of the study (n = 14). Internal organs were removed from the abdominal (viscera) and thoracic cavity (pluck). Digestive contents and adhering adipose tissue were removed from the gastrointestinal tract before weighing the stomach complex (reticulorumen, omasum, and abomasum) and lower tract (duodenum through anus). Weights of the entire digesta-free gastro-intestinal tract (separated into reticulorumen, omasum, abomasum, small and large intestine), liver, spleen, heart, lungs with trachea, and adipose tissue were recorded.

Statistical Analysis. Feedlot performance and carcass characteristics were analyzed using the GLM procedure of SAS (1985). Steer was the experimental unit for performance, carcass data, and meat quality. The model included year, treatment, breed, and their interactions as independent variables. There was no interactions (P > .10), so the data were pooled over years. Breed means were compared (orthogonal contrasts; Steel and Torrie, 1980) by the following contrasts: 1) BRI vs CON, and 2) BRI vs WAG.

The model for visceral organ mass included treatment as an independent variable and external fat thickness as a covariate.

RESULTS AND DISCUSSION

Effect of Growing Treatment on Steer Performance. No differences (P = .45) were observed between growing treatments for initial and slaughter weights (Table 3). The CONC steers were fed 46 more d than PAST steers (P = .0001). Duckett et al. (1993) reported that intramuscular fat deposition seemed to be a function of the number of d that cattle are exposed to a high-concentrate diets. Duckett et al. (1993) found that approximately 112 d on a high-concentrate diet was needed for yearling, British-cross steers to reach Choice quality grade. Steers in this experiment were fed 268 and 222 d for the CONC and PAST treatments, respectively. Lunt and Orme (1987) stated that fat thickness, rather than weight, is the most important factor in determining slaughter readiness. This is because when cattle are grown at an accelerated pace, adipose tissue accretion is greater than that observed in cattle grown at a slower rate (Lunt and Orme, 1987). Therefore, to obtain the same carcass composition, cattle which are fed an energy-dense diet soon after weaning would need to be slaughtered at a lighter weight than cattle which are fed on forage for a period of time prior to finishing (Lunt and Orme, 1987). This may be true for calves weaned at about 205 d of age but it is not consistent with our results on early weaned steers. The CONC steers were 37 d younger (P = .0002) than PAST at slaughter, 394 and 431 d, respectively.

The CONC steers exhibited .85 kg/d higher ADG (P = .0001) than PAST steers prior to 208 d of age. Lancaster et al. (1973) conducted a 194-d feeding trial to compare the feedlot performance of 205-d-old calves placed directly on a high concentrate finishing ration with calves allowed a growing period of 76 d before being placed on the finishing ration. At the end of the 76-d growing period, the steers on the high concentrate finishing ration were 19.5 kg heavier and had gained .28 kg/d more than the steers on the high roughage grower ration. The PAST steers had .12 kg/d higher ADG (P = .008) than CONC steers after d 208. Lancaster et al. (1973) observed similar results and reported that the grower ration steers had a .18 kg advantage in average daily gain, which resulted in typical compensatory growth characteristics being exhibited by the steers previously fed the grower ration. The CONC steers had .17 kg/d higher ADG (P = .0001) overall. Oltjen et al. (1971) reported that steers fed a forage diet initially did not sufficiently out gain steers on a continuous high concentrate diet when both groups were on a high concentrate diet to compensate for the differences in ADG that occurred initially. Thus, the steers on a continuous high concentrate diet in their study showed a slight advantage in ADG over the entire feeding trial.

No differences (P = .57) were observed for initial height between growing treatments. CONC steers had 2.8 cm more height change (P = .0001) than PAST prior to 208 d. Lancaster et al. (1973)

observed similar results, as change in wither height during the first period was 1.57 cm more for the steers on the finishing ration, and suggested that structural growth occurred at a faster rate on the finishing ration than on the grower ration. However, PAST steers had 2.2 cm more height change (P = .01) than CONC steers after 208 d. No differences (P = .44) due to growing treatment was observed in height change overall.

The feedlot performance of CONC steers from 127 to 208 d of age shows that young calves are extremely efficient (Table 4). Steers consumed 4.58 kg/d and exhibited a gain:feed ratio of .287. Intake was not affected (P = .51) by growing treatment between 208 and 413 d of age, but PAST steers had .012 units (gain:feed) better feed conversions (P = .009) compared to CONC steers. From 208 to 413 d of age, steers consumed 1.7, and 1.9% of body weight for the CONC and PAST treatments, respectively. This may help explain some of the differences observed in efficiency overall. Although these intakes are lower than typical feedlot cattle, they are consistent with Fox et al. (1988) which suggested a 10% decrease in predicted DMI by cattle started on feed as calves compared with cattle started on feed as yearlings. Lipsey et al. (1978) and Loveday and Dikeman (1980) report this may have been due to the fact that CONC steers had higher maintenance-energy requirements and greater requirements for depositing tissue because they were heavier and were depositing more fat. However, Lancaster et al. (1973) reported that accelerated steers were more efficient than conventional steers. Overall, CONC steers had 1.09 kg/d lower intake (P = .0001) and .01 units better feed conversion (P = .008) than PAST steers. Lancaster et al. (1973) indicated that steers on the finishing ration were slightly more efficient in terms of converting feed to weight gain. Feeding steers concentrate from 127 d of age did not affect total concentrate consumed (P = .97).

Effect of Breed Type on Steer Performance. The effects of breed type on performance traits are shown in Tables 5 and 6. The CON steers were 18 kg heavier (P = .02) than the BRI steers on d 127 of age, and 66 kg heavier at slaughter (P = .0001). There were no differences (P > .31) in initial and slaughter weights between the BRI and WAG steers.

Differences (P < .05) existed between breed types for the number of days steers were fed the finishing diet (Table 5). BRI steers required 31 fewer days than CON steers (P = .008), and 23 fewer d than WAG steers (P = .05) when fed to a fat constant endpoint. Greene et al. (1989) found that only approximately 65 d were needed for purebred Angus steers to reach Choice grade, whereas Zinn et al. (1970) reported that 210 d were necessary for purebred Hereford steers fed an 80% concentrate diet to reach Choice grade. The BRI steers were 44 d younger than CON (P = .0003), and 47 d younger than WAG steers (P = .0002) when slaughtered at a fat constant endpoint (382, 426, and 429 d for BRI, CON, and WAG steers, respectively).

The ADG from 127 to 208 d of age was not affected (P > .12) by breed type. The ADG between BRI and CON steers was not different (P > .58) from 208 to 413 d of age or overall. However, breed type influenced ADG between BRI and WAG steers. The BRI steers had .19 kg/d higher ADG (P = .0007) than WAG steers after 208 d of age. Similar results were observed for overall ADG as BRI steers exhibited .16 kg/d higher ADG (P = .0003) than WAG steers. The results are consistent with Myers et al. (1998).

The BRI steers were 4.5 cm shorter (P = .0005) than CON steers on d 127 of age. No differences (P = .44) were observed for height change between BRI and CON steers throughout the experiment.

However, breed type did affect height change between BRI and WAG steers differently during the two phases. The WAG steers tended (P = .06) to have 1.1 cm more height change prior to 208 d of age than BRI steers, but BRI steers had 2.5 cm more (P = .02) height change after 208 d of age. No differences (P = .19) in overall height change were observed between BRI and WAG steers.

The BRI steers tended (P = .09) to have lower intake than CON steers from 127 to 208 d of age (Table 6). No differences (P > .26) were observed between BRI and CON steers in intake after 208 d of age or overall intake. Differences in intake were not statistically significant (P = .13) between BRI and WAG steers between 127 and 208 d of age. However, the BRI steers had .63 kg/d higher intake (P = .03) than WAG steers after d 208, and tended (P = .07) to have .49 kg/d higher intake overall.

During the first 82 d of the trial, efficiency tended (P = .09) to be .02 (gain:feed) units higher for the BRI steers than CON steers. No breed differences (P > .22) between BRI and CON steers were observed for efficiency after 208 d of age or overall. The BRI steers had .03 units better feed conversions (P = .03) than the WAG steers from 127 to 208 d of age. The BRI steers tended to exhibit .01 units better gain:feed than WAG steers after 208 d of age (P = .06) and overall (P = .10). Findings of Lunt et al. (1993) also gives further evidence that Angus steers require less feed per unit of gain than Wagyu steers. These findings agree with Myers et al. (1998). When compared to CON steers, BRI steers consumed 310 kg less total concentrate (P = .0003). No difference (P = .60) in total concentrate consumed were observed between the BRI and WAG steers. These results are consistent with Myers et al. (1998).

Carcass Evaluation. In general, carcass traits were similar (P > .05) between growing treatments (Table 7). No differences (P > .38) were observed between growing treatments for carcass weight, external fat thickness, LMA, LMA expressed as square centimeter per kilogram of hot carcass weight, kidney, pelvic, and heart fat, and yield grade. Sixty-eight percent of the steers graded with a yield grade of 2.9 or better, having an average yield grade of 2.8. Lancaster et al. (1973) indicated carcass traits were similar for 205-d-old calves placed directly on a high concentrate finishing ration with calves allowed a growing period of 76 d before being placed on the finishing ration.

No differences (P = .92) were observed between growing treatments for marbling score. Eighty-nine percent of the carcasses in both treatments graded Choice or higher. The CONC steers tended (P = .11) to improve percentage of carcasses grading Average Choice or higher by 47% over those steers grown on pasture for 82 d. No differences (P = .19) were observed in percentage of carcasses grading Prime or higher. Lancaster et al. (1973) reported significantly higher marbling scores for steers weaned to 205 d of age placed directly on a high concentrate finishing ration than those allowed a 76-d growing period. Dahman et al. (1962) found that steers fed a low level of concentrates for the first 140 d of feeding had a smaller amount of marbling than steers fed a higher level of concentrate.

Carcass quality characteristics by breed type are presented in Table 8. Because of greater live weights, CON steers had a 40 kg heavier carcass weight (P = .0001) at a fat thickness equivalent to that of BRI steers. There were no breed differences (P = .31) in carcass weight between the BRI and WAG steers. The BRI and WAG breed types resulted in 21 and 26 percentage units, respectively, of carcasses below 250 kg; however, steers of CON breed type resulted in no light carcasses. No differences (P > .47) were observed between breeds for external fat thickness, which was expected since steers were harvested at a constant external fat thickness as measured by ultrasound. Compared to BRI steers, CON steers measured with 7.2 sq cm larger (P = .0006) LMA. No differences (P = .27) were observed for LMA between the BRI and WAG steers. When expressed as square centimeters per kilogram of hot carcass weight, CON steers tended (P = .09) to have smaller LMA and WAG steers had larger LMA (P = .01) than BRI steers. There were no differences (P = .72) in percentage of kidney, pelvic, and heart fat between BRI and CON steers; however, BRI had .20 percentage units less (P = .03) than WAG steers.

Breed type did not result in a difference (P > .19) in yield grade, or the percentage of carcasses grading yield grade 1, 2, or 3, which would be expected when steers are slaughtered at equivalent external fat thickness endpoint.

No differences (P > .27) were observed for marbling score between BRI and CON steers, or the percentage of carcasses grading greater than or equal to Choice, Average Choice, or Prime. WAG steers had a 76 unit higher marbling score (P = .006) than BRI steers. This resulted in 19% more (P = .09) carcasses grading greater than or equal to Choice, and 82% more (P = .03) grading greater than or equal to Average Choice. No differences (P = .11) were observed in the percentage of carcasses grading greater than or equal to Prime.

Meat Quality Measurements. Steak weights and cooking parameters by growing treatment and breed type are presented in Tables 9 and 10. No differences (P > .55) were observed between growing treatment for raw weight, cooking loss, or percentage cooking loss. The raw weight of the CON steaks were 22.63 g heavier (P = .007) than BRI steers. This would be expected since CON were 66 kg heavier (P = .0001) at slaughter, had 40 kg heavier carcass weight (P = .0001), and measured with 7.2 sq cm larger (P = .0006) LMA. The CON steers had more cooking loss (P = .05) than BRI steers. There were no differences (P > .22) in raw weight, or cooking loss between BRI and WAG steaks. Breed type did not result in a differences (P > .62) in percentage cooking loss.

The effects of growing treatment and breed type on proximate composition of the 9-10-11 rib are shown in Tables 9 and 10. No differences (P > .16) were observed in the percentage of moisture, protein, or ether extract between growing treatments. There were no differences (P > .45) in the proximate composition of the 9-10-11 rib between BRI and CON breed types. The WAG steers tended (P = .11) to have a lower moisture percentage and higher percentage of ether extract (P = .12) than BRI steers. Lunt et al. (1993) reported that Wagyu crossbred steers had an average of 4.4% more ether extractable fat from the ribeye muscle than Angus steers. The 9-10-11 rib of the BRI steers did have a .58 percentage units higher protein percentage (P = .04) than WAG steers.

Growing treatment did not have an affect on the sensory attributes and shear force of ribeye steaks (Table 9). No differences (P > .35) were observed between growing treatments for tenderness, juiciness, off-flavor, and shear force. These results are consistent with Dikeman et al. (1985b) who reported that taste panel evaluations of meat from cattle produced under accelerated nutritional management and that of conventionally produced beef were not different. Additionally, Tatum et al. (1980) concluded that steaks from steers fed 100 d or longer on a high-concentrate diet were similar in palatability, irrespective of quality grade. However, McBee and Wiles (1967) reported that tenderness, juiciness, and flavor increased with increasing degrees of marbling in a direct, linear relationship. McKeith et al. (1985) found that longissimus muscle steaks from Angus steers became acceptable in sensory tenderness between 56 and 112 d of feeding.

In general, no differences ($P > .19$) were observed for sensory evaluation and shear force of ribeye steaks between BRI and CON steers (Table 10). Similar results were observed between BRI and WAG steers. However, WAG steers tended ($P = .07$) to have a greater incidence of off-flavor than BRI steers. Koch et al. (1976) indicated little difference in tenderness, flavor, juiciness, or overall acceptability scores for meat samples from crossbreds sired by Angus, Hereford, Jersey, South Devon, Limousin, Simmental, or Charolais bulls. Fredeen et al. (1972) found no differences among breeds in tenderness (shear force and sensory panel data) of the longissimus muscle. Adams et al. (1977) found no differences in palatability among breed groups, including several British and French crossbred breed-types. Dikeman and Crouse (1975) detected no differences in palatability among Hereford x Angus, Limousin x Angus, or Simmental x Angus crosses fed 200 to 284 d. May et al. (1993) indicated that consumers could detect differences between steaks from Angus and Wagyu steers in a consumer triangle test.

Visceral Measurements. The effect of growing treatment on digestive tract weights expressed as a percentage of hot carcass weight are presented in Table 11. Growing treatment did not result in a difference ($P > .17$) in the weights of the heart, abomasum, omasum, intestines, combined weight (rumen, abomasum, omasum, and small and large intestines), and fat as a percentage of hot carcass weight. The PAST steers tended ($P = .15$) to have a 12% larger liver weight and 14% larger ($P = .01$) rumen weight in respect to CONC steers. Studies have demonstrated that maintenance energy requirements are influenced by factors other than body size, such as age (Graham et al., 1974), breed (Smith and Baldwin, 1974; Jenkins and Ferrell, 1983), temperature (Close and Mount, 1978), and plane of nutrition (Ledger and Sayers, 1977).

Burrin et al. (1989) suggest that changes in visceral-organ growth in response to level of nutrition are associated with concurrent changes in blood flow and O_2 consumption of visceral tissues. Huntington and Prior (1983) and Huntington (1984) have indicated a positive relation between feed intake and portal blood flow in sheep and cattle. Changes in portal blood flow occur during all phases of nutrient assimilation in animals. Canas et al. (1982) evaluated the effects of food intake on organ weights in lactating and nonlactating rats. Their data indicated that during lactation, when feed intake is about twice that of nonlactating animals, weights of the intestine, liver, and heart increase. These organs have higher energy requirements per unit mass than the body average. These observations imply that when food intake increases, hypertrophy occurs in organs that have high maintenance energy expenditures per unit of weight. In the current study, the relative intakes of the steers during the growing phase were not evaluated; however, the above results may be part of that explanation.

Researchers have reported increased portal blood flow after feeding (Huntington, 1982; Bensadoun and Reid, 1962) or as a result of changing the diet from a forage to a high concentrate (Huntington et al., 1981; Huntington, 1983). It is reasonable to expect a relationship between digestion in the gut and the transport mechanism to remove absorbed nutrients.

CONCLUSIONS

Steers placed directly on high concentrate after weaning had higher gain, lower intake, better efficiency, were younger at slaughter, consumed the same amount of total concentrate, and had reduced liver and rumen weights when compared to steers grown on pasture prior to finishing. Steers of British breed type reduced slaughter weights, reduced finishing days, reduced total concentrate consumed, reduced carcass weights, increased percentage of light carcasses, and reduced longissimus muscle area compared to steers of Continental breed type. Steers of Wagyu breed type had more days in the feedlot, lower gain, lower intake, more undesirable efficiencies, consumed the same amount of total concentrate, and improved quality grades compared to steers of British breed type in this study.

LITERATURE CITED

Adams, N. J., G. C. Smith, and Z. L. Carpenter. 1977. Carcass and palatability characteristics of Hereford and crossbred steers. J. Anim. Sci. 46:438-448.

American Meat Science Association. 1978. Guidelines for cookery and sensory evaluation of meat. American Meat Science Association-National Livestock and Meat Board, Chicago, IL.

AOAC. 1992. Official Methods of Analysis (16th Ed.). Association of Official Analytical Chemists, Washington, DC.

Bartle, S. J., J. R. Males, and R. L. Preston. 1984. Effect of energy intake on the postpartum interval in beef cows and the adequacy of the cow's milk production for calf growth. J. Anim. Sci. 58:1068-1074.

Bensadoun, A., and J. T. Reid. 1962. Estimation of rate of portal blood flow in ruminants: Effect of feeding, fasting, and anesthesia. J. Dairy Sci. 45:540-543.

Burrin, D. G., C. L. Ferrell, R. A. Britton, and M. Bauer. 1990. Level of nutrition and visceral organ size and metabolic activity in sheep. Br. J. Nutr. 64:439-448.

Burrin, D. G., C. L. Ferrell, J. H. Eisemann, R. A. Britton, and J. A. Nienaber. 1989. Effect of level of nutrition on splanchnic blood flow and oxygen consumption in sheep. Br. J. Nutr. 62:23-34.

Canas, R., J. J. Romero, and R. L. Baldwin. 1982. Maintenance energy requirements during lactation in rats. J. Nutr. 112:1876-1880.

Close, W. H., and L. E. Mount. 1978. The effects of plane of nutrition and environmental temperature on the energy metabolism of the growing pig. 1. Heat loss and critical temperature. Br. J. Nutr. 40:413-421.

Cover, S., O. D. Butler, and T. C. Cartwright. 1956. The relationship of fatness in yearling steers to juiciness and tenderness of broiled and braised steaks. J. Anim. Sci. 15:464-472.

Dahmen, J. J., T. B. Keith, and T. D. Bell. 1962. Delayed concentrate feeding to steers. Idaho Agric. Exp. Sta. Bull. No. 374.

DeHaan, K. C., L. L. Berger, D. J. Kesler, F. K. McKeith, D. B. Faulkner, G. F. Cmarik, and R. J. Favero. 1990. Effects of prenatal testosterone treatment and postnatal steroid implantation on growth performance and carcass traits of heifers and steers. J. Anim. Sci. 68:2198-2207.

Dikeman, M. E., and J. D. Crouse. 1975. Chemical composition of carcasses from Hereford, Limousin and Simmental crossbred cattle as related to growth and meat palatability. J. Anim. Sci. 40:463-467.

Dikeman, M. E., A. D. Dayton, M. C. Hunt, C. L. Kastner, J. B. Axe, and H. J. Ilg. 1985a. Conventional versus accelerated beef production with carcass electrical stimulation. J. Anim. Sci. 61:573-583.

Dikeman, M. E., K. N. Nagele, S. M. Myers, R. R. Schalles, D. H. Kropf, C. L. Kastner, and F. A. Russo. 1985b. Accelerated versus conventional beef production and processing. J. Anim. Sci. 61:137-150.

Duckett, S. K., D. G. Wagner, L. D. Yates, H. G. Dolezal, and S. G. May. 1993. Effects of time on feed on beef nutrient composition. J. Anim. Sci. 71:2079-2088.

Ferrell, C. L., and L. J. Koong. 1986. Influence of plane of nutrition on body composition, organ size and energy utilization of Sprague-Dawley rats. J. Nutr. 116:2525-2535.

Fox, D. G., C. J. Sniffen, and J. D. O'Connor. 1988. Adjusting nutrient requirements of beef cattle for animal and environmental variation. J. Anim. Sci. 66:1475-1495.

Fredeen, H. T., A. H. Martin, G. M. Weiss, S. B. Slen, and L. J. Sumption. 1972. Feedlot and carcass performance of young bulls representing several breeds and breed crosses. Can. J. Anim. Sci. 52:241-257.

Graham, N. McC., T. W. Searle, and D. A. Griffiths. 1974. Basal metabolic rate in lambs and young sheep. Aust. J. Agric. Res. 25:957-971.

Greene, B. B., W. R. Backus, and M. J. Riemann. 1989. Changes in lipid content of ground beef from yearling steers serially slaughtered after varying lengths of grain finishing. J. Anim. Sci. 67:711-715.

Hankins, O. G., and P. E. Howe. 1946. Estimation of the composition of beef carcasses and cuts. USDA Tech. Bull. 926, Washington, DC.

Huntington, G. B. 1982. Portal blood flow and net absorption of ammonia-nitrogen, urea-nitrogen, and glucose in nonlactating Holstein cows. J. Dairy Sci. 65:1155-1162.

Huntington, G. B. 1983. Net nutrient absorption in beef steers fed silage or high concentrate diets containing four levels of limestone. J. Nutr. 113:1157-1164.

Huntington, G. 1984. Relationship of portal blood flow to metabolizable energy intake of cattle. Can. J. Anim. Sci. 64(Suppl.):16-17.

Huntington, G. B., and R. L. Prior. 1983. Digestion and absorption of nutrients by beef heifers fed a high concentrate diet. J. Nutr. 113:2280-2288.

Huntington, G. B., R. L. Prior, and R. A. Britton. 1981. Glucose and lactate absorption and metabolic interrelationships in steers changed from low to high concentrate diets. J. Nutr. 111:1164-1172.

Jenkins, T. G., and C. L. Ferrell. 1983. Nutrient requirements to maintain weight of mature, nonlactating, nonpregnant cows of four diverse breed types. J. Anim. Sci. 56:761-770.

Koch, R. M., M. E. Dikeman, D. M. Allen, M. May, J. D. Crouse, and D. R. Campion. 1976. Characterization of biological types of cattle. III. Carcass composition, quality, and palatability. J. Anim. Sci. 43:48-62.

Koong, L. J., J. A. Nienaber, J. C. Pekas, and J. T. Yen. 1982. Effects of plane of nutrition on organ size and fasting heat production in pigs. J. Nutr. 112:1638-1642.

Lancaster, L. R., R. R. Frahm, and D. R. Gill. 1973. Comparative feedlot performance and carcass traits between steers allowed a postweaning growing period and steers placed on a finishing ration at weaning. J. Anim. Sci. 37:632-636.

Ledger, H. P., and A. R. Sayers. 1977. The utilization of dietary energy by steers during periods of restricted food intake and subsequent realimentation. I. The effect of time on maintenance requirements of steers held at constant live weights. J. Agric. Sci. 88:11-26.

Lipsey, R. J., M. E. Dikeman, and R. R. Schalles. 1978. Carcass composition of different cattle types related to energy efficiency. J. Anim. Sci. 46:96-101.

Loveday, H. D., and M. E. Dikeman. 1980. Diet energy and steer type effects on adipose composition, lipogenesis and carcass composition. J. Anim. Sci. 51:78-88.

Lunt, D. K., and L. E. Orme. 1987. Feedlot performance and carcass evaluation of heifers fed finishing diets as weanling calves or as yearlings. Meat Sci. 20:159-164.

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.

May, S. G., C. A. Sturdivant, D. K. Lunt, R. K. Miller, and S. B. Smith. 1993. Comparison of sensory characteristics and fatty acid composition between Wagyu crossbred and Angus steers. Meat Sci. 35:289-298.

McBee, J. L., Jr., and J. A. Wiles. 1967. Influence of marbling and carcass grade on the physical and chemical characteristics of beef. J. Anim. Sci. 26:701-704.

McKeith, F. K., J. W. Savell, G. C. Smith, T. R. Dutson, and Z. L. Carpenter. 1985. Tenderness of major muscles from three breed-types of cattle at different times-on-feed. Meat Sci. 13:151-166.

Myers, S. E, D. B. Faulkner, F. A. Ireland, L. L. Berger, and D. F. Parrett. 1998. Production Systems Comparing Early Weaning to Normal Weaning With or Without Creep Feeding for Beef Steers. J. Anim. Sci. 76(In press).

Novakofski, J., S. Park, P. J. Bechtel, and F. K. McKeith. 1989. Composition of cooked pork chops: Effect of removing subcutaneous fat before cooking. J. Food Sci. 54(1):15-17.

Oltjen, R. R., T. S. Rumsey, and P. A. Putnam. 1971. All-forage diets for finishing beef cattle. J. Anim. Sci. 32:327-333.

Palmer, A. Z., J. W. Carpenter, R. L. Alsmeyer, H. L. Chapman, and W. G. Kirk. 1958. Simple correlations between carcass grade, marbling, ether extract of loin eye and beef tenderness. J. Anim. Sci. 17:1153 (Abstr.).

Ridenour, K. W., H. E. Kiesling, G. P. Lofgreen, and D. M. Stiffler. 1982. Feedlot performance and carcass characteristics of beef steers grown and finished under different nutrition and management programs. J. Anim. Sci. 54:1115-1119.

Robison, O. W., M.K.M. Yusuff, and E. U. Dillard. 1978. Milk production in Hereford cows: I. Means and correlations. J. Anim. Sci. 47:131-141.

SAS. 1985. SAS User's Guide: Statistics (Version 5 Ed.). SAS Inst. Inc., Cary, NC.

Smith, N. E., and R. L. Baldwin. 1974. Effects of breed, pregnancy, and lactation on weight of organs and tissues in dairy cattle. J. Dairy Sci. 57:1055-1060.

Steel, R.G.D., and J. H. Torrie. 1980. Principles and Procedures of Statistics: A Biometrical Approach (2nd Ed.). McGraw-Hill Publishing Co., New York.

Tatum, J. D., G. C. Smith, B. W. Berry, C. E. Murphey, F. L. Williams, and Z. L. Carpenter. 1980. Carcass characteristics, time on feed and cooked beef palatability attributes. J. Anim. Sci. 50:833-840.

USDA. 1975. Official United States Standards for Grades of Carcass Beef. USDA Food Safety and Quality Serv., Washington, DC.

Webster, A.J.F. 1981. The energetic efficiency of metabolism. Proc. Nutr. Soc. 40:121-128.

Whipple, G., M. Koohmaraie, M. E. Dikeman, and J. D. Crouse. 1990. Predicting beef-longissimus tenderness from various biochemical and histological muscle traits. J. Anim. Sci. 68:4193-4199.

Zinn, D. W., R. M. Durham, and H. B. Hedrick. 1970. Feedlot and carcass grade characteristics of steers and heifers as influenced by days on feed. J. Anim. Sci. 31:302-306.

Table 1. Composition of finishing diets fed to steers

	Diet sequence, %[a]			
Ingredients	1	2	3	4
NH_3 cobs	45.0	33.0	23.0	13.0
Dry corn	45.0	57.0	67.0	77.0
Supplement	10.0	10.0	10.0	10.0
Feed Analysis				
Crude protein, %	9.19	9.69	10.11	10.53
NE_M, Mcal/kg	.44	.47	.50	.52
NE_G, Mcal/kg	.28	.31	.33	.35

[a]DM basis.

Table 2. Ingredient composition of pelleted supplement fed to steers

Ingredient	%[a]
Soybean meal	68.75
Thiamine 8.8%, 88,000 mg/kg	.15
Monensin-80[b]	.15
Copper sulfate acidified	.05
Potassium chloride	1.50
Urea	7.52
Dried molasses	2.58
Blood meal	3.20
Vitamin ADE[c]	.15
Swine trace mineralized salt[d]	3.50
Limestone	10.00
Dicalcium phosphate	2.50

[a]DM basis.
[b]Contains 176 g of monensin/kg.
[c]Composition (per gram): ≥3,300 IU vitamin A, ≥330 IU vitamin D_3, and ≥44 IU vitamin E.
[d]Composition (%): NaCl (82 to 87), Fe (≥2.57), Zn (≥2.86), Mn (≥.57), Cu (≥.23), I (≥.01), Se (≥.009).

Table 3. Performance of early weaned steers receiving a high concentrate diet or grown on pasture prior to finishing[a]

	Growing treatments			
Item	Concentrate	Pasture	SEM[b]	P =
No. of steers	36	36		
Initial wt, kg	144	149	4	.45
Slaughter wt[c], kg	488	491	9	.79
Days on pasture	- -	82	- -	- -
Days in feedlot	268	222	7	.0001
ADG, kg				
127-208 d of age	1.33	.48	.03	.0001
208-413 d of age	1.28	1.40	.03	.008
Overall	1.30	1.13	.02	.0001
Initial ht, cm	100.1	100.7	.73	.57
Height change, cm				
127-208 d of age	8.9	6.1	.3	.0001
208-413 d of age	15.9	18.1	.6	.01
Overall	24.9	24.1	.7	.44

[a]Least squares means.
[b]Greatest standard error of treatment means (SEM) reported.
[c]Calculated as hot carcass weight/.61.

Table 4. Performance of early weaned steers receiving a high concentrate diet or grown on pasture prior to finishing[a]

	Growing treatments			
Item	Concentrate	Pasture	SEM[b]	P =
No. of steers	36	36		
DMI, kg/d[c]				
127-208 d of age	4.58	- -	.14	- -
208-413 d of age	7.75	7.90	.17	.51
Overall	6.81	7.90	.16	.0001
Gain/feed[c]				
127-208 d of age	.287	- -	.004	- -
208-413 d of age	.165	.177	.003	.009
Overall	.190	.177	.003	.008
Total conc., kg/hd[d]	1,816	1,814	48	.97

[a]Least squares means.
[b]Greatest standard error of treatment means (SEM) reported.
[c]During finishing phase.
[d]Total concentrate, finishing and supplement on pasture included.

Table 5. Performance of early weaned steers of three breed types receiving a high concentrate diet or grown on pasture prior to finishing[a]

					P =	
					Contrast	
					BRI	BRI
	Breeds[b]				vs	vs
Item	BRI	CON	WAG	SEM[c]	CON	WAG
No. of steers	24	24	24			
Initial wt, kg	140	158	142	6	.02	.85
Slaughter wt[d], kg	473	539	457	11	.0001	.31
Days in feedlot	227	258	250	8	.008	.05
ADG, kg						
127-208 d of age	.89	.98	.85	.04	.12	.49
208-413 d of age	1.41	1.39	1.22	.04	.78	.0007
Overall	1.26	1.28	1.10	.03	.58	.0003
Initial ht, cm	98.7	103.2	99.2	.92	.0005	.67
Height change, cm						
127-208 d of age	7.0	7.4	8.1	.4	.44	.06
208-413 d of age	17.8	18.0	15.3	.7	.85	.02
Overall	24.8	25.4	23.2	.9	.60	.19

[a]Least squares means.

[b]BRI = ¾ Angus x ¼ Simmental, CON = ¾ Simmental x ¼ Angus, WAG = ½ Wagyu x ¼ Angus x ¼ Simmental.

[c]Greatest standard error of treatment means (SEM) reported.

[d]Calculated as hot carcass weight/.61.

Table 6. Performance of early weaned steers of three breed types receiving a high concentrate diet or grown on pasture prior to finishing[a]

					P =	
					Contrast	
					BRI	BRI
	Breeds[b]				vs	vs
Item	BRI	CON	WAG	SEM[c]	CON	WA
No. of steers	24	24	24			
DMI, kg/d[d]						
127-208 d of age	4.21	4.80	4.74	.24	.09	.13
208-413 d of age	7.98	8.16	7.35	.20	.52	.03
Overall	7.42	7.72	6.93	.19	.26	.07
Gain/feed[d]						
127-208 d of age	.302	.283	.277	.008	.09	.03
208-413 d of age	.177	.172	.166	.004	.38	.06
Overall	.189	.182	.180	.004	.22	.10
Total conc., kg/hd[e]	1,697	2,007	1,740	59	.0003	.60

[a]Least squares means.

[b]BRI = ¾ Angus x ¼ Simmental, CON = ¾ Simmental x ¼ Angus, WAG = ½ Wagyu x ¼ Angus x ¼ Simmental.

[c]Greatest standard error of treatment means (SEM) reported.

[d]During finishing phase.

[e]Total concentrate, finishing and supplement on pasture included.

Table 7. Carcass quality of early weaned steers receiving a high concentrate diet or grown on pasture prior to finishing[a]

	Growing treatments			
Item	Concentrate	Pasture	SEM[b]	P =
No. of steers	36	36		
Carcass wt, kg	298	300	5	.79
≤250 kg, %	13	16	5	.67
External fat thickness, cm	1.16	1.17	.05	.82
LMA[c]				
Sq cm	75.7	76.8	1.17	.51
Sq cm/kg HCW[d]	.26	.26	.01	.54
Est. KPH[e] , %	2.0	1.9	.1	.38
Avg. Yield grade	2.81	2.77	.07	.72
Yield grade 1, %	0	3	2	.26
Yield grade 2, %	66	66	8	.97
Yield grade 3, %	34	31	8	.74
Marbling score[f]	1,091	1,093	15	.92
≥Choice, %	89	89	5	.95
≥Avg. Choice, %	56	38	8	.11
≥Prime, %	2	10	4	.19

[a]Least squares means.
[b]Greatest standard error of treatment means (SEM) reported.
[c]Longissimus muscle area.
[d]Hot carcass weight.
[e]Kidney, pelvic, heart fat.
[f]1,000 = Small^{00}.

Table 8. Carcass quality of early weaned steers of three breed types receiving a high concentrate diet or grown on pasture prior to finishing[a]

					P =	
					Contrast	
					BRI	BRI
	Breeds[b]				vs	vs
Item	BRI	CON	WAG	SEM[c]	CON	WAG
No. of steers	24	24	24			
Carcass wt, kg	289	329	279	7	.0001	.31
≤250 kg, %	21	0	26	7	.01	.60
External fat						
thickness, cm	1.19	1.13	1.17	.06	.47	.75
LMA[d]						
Sq cm	73.1	80.3	75.3	1.45	.0006	.27
Sq cm/kg	.26	.25	.27	.01	.09	.01
Est. KPH[f] , %	1.9	1.9	2.1	.1	.72	.03
Avg. Yield grade	2.86	2.81	2.70	.09	.65	.19
Yield grade 1, %	4	0	0	2	.20	.30
Yield grade 2, %	58	64	76	10	.66	.21
Yield grade 3, %	38	36	24	10	.91	.31
Marbling score[g]	1,063	1,073	1,139	19	.70	.006
≥Choice, %	83	84	99	7	.97	.09
≥Avg. Choice, %	38	34	69	10	.82	.03
≥Prime, %	0	7	11	5	.27	.11

[a]Least squares means.

Table 9. Steak weights, cooking parameters, proximate composition, and sensory attributes of early weaned steers receiving a high concentrate diet or grown on pasture prior to finishing[ab]

	Growing treatments			
Item	Concentrate	Pasture	SEM[c]	P =
Raw weight, g	200.09	203.93	4.65	.56
Cooking loss, g	48.50	50.05	1.84	.55
Cooking loss, %	24.21	24.74	.80	.65
Moisture, %[d]	47.09	47.37	.48	.68
Protein, %[d]	13.56	13.67	.16	.63
Lipid, %[d]	39.24	38.62	.60	.47
Tenderness[ef]	9.75	9.62	.32	.78
Juiciness[ef]	10.23	10.51	.27	.47
Off-flavor[ef]	14.78	14.70	.06	.35
Shear force, kg[g]	4.48	4.63	.15	.47

[a]Least squares means.
[b]External fat thickness was used as a covariate (mean = 1.17 cm).
[c]Greatest standard error of treatment means (SEM) reported.
[d]Proximate composition of the 9-10-11 rib.
[e]Sensory attributes of ribeye steaks.
[f]Evaluated by a trained sensory panel on a 15-cm continuous scale; 15 = tender, juicy, no off-flavors.
[g]Warner-Bratzler shear, peak force.

Table 10. Steak weights, cooking parameters, proximate composition, and sensory attributes of early weaned steers of three breed types receiving a high concentrate diet or grown on pasture prior to finishing[ab]

					P =	
					Contrast	
					BRI	BRI
	Breeds[c]				vs	vs
	BRI	CON	WAG	SEM[d]	CON	WAG
Raw weight, g	191.15	213.78	201.09	5.72	.007	.22
Cooking loss, g	46.08	52.36	49.39	2.26	.05	.30
Cooking loss, %	24.14	24.44	24.84	.99	.83	.62
Moisture, %[e]	47.89	47.26	46.53	.59	.46	.11
Protein, %[e]	13.75	13.92	13.17	.19	.56	.04
Lipid, %[e]	38.11	38.91	39.76	.74	.45	.12
Tenderness[fg]	9.28	10.01	9.76	.39	.19	.38
Juiciness[fg]	10.35	10.36	10.41	.34	.99	.91
Off-flavor[fg]	14.79	14.83	14.60	.07	.67	.07
Shear force, kg[h]	4.59	4.68	4.41	.18	.72	.48

[a]Least squares means.
[b]External fat thickness was used as a covariate (mean = 1.17 cm).
[c]BRI = ¾ Angus x ¼ Simmental, CON = ¾ Simmental x ¼ Angus, WAG = ½ Wagyu x ¼ Angus x ¼ Simmental.
[d]Greatest standard error of treatment means (SEM) reported.
[e]Proximate composition of the 9-10-11 rib.
[f]Sensory attributes of ribeye steaks.
[g]Evaluated by a trained sensory panel on a 15-cm continuous scale; 15 = tender, juicy, no off-flavors.
[h]Warner-Bratzler shear, peak force.

Table 11. Digestive tract weights of early weaned steers receiving a high concentrate diet or grown on pasture prior to finishing[ab]

	Growing treatments			
Item	Concentrate	Pasture	SEM[c]	P =
No. of steers	7	7		
Liver, %[d]	1.79	2.01	.10	.15
Heart, %[d]	.51	.53	.10	.65
Rumen, %[d]	3.18	3.61	.10	.01
Abomasum, %[d]	.47	.45	.03	.55
Omasum, %[d]	.96	1.03	.08	.58
Intestines, %[de]	2.24	2.25	.15	.96
Combined, %[df]	6.84	7.33	.23	.17
Fat, %[d]	8.24	8.62	.40	.53
Carcass wt, kg	333	310	15	.31

[a]Least squares means.
[b]External fat thickness was used as a covariate (mean = 1.01 cm).
[c]Greatest standard error of treatment means (SEM) reported.
[d]Percentage of hot carcass weight.
[e]Small and large intestines.
[f]Rumen, abomasum, omasum, and small and large intestines.