Performance and Carcass Traits of Early-Weaned Steers Receiving Either a Pasture Growing Period or a Finishing Diet at Weaning¹

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ABSTRACT: 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 earlyweaned (117 d of age) steers. Potential breed differences were evaluated using crossbred steers of three types: 1) $\frac{3}{4}$ Angus $\times \frac{1}{4}$ Simmental (BRI), 2) $\frac{3}{4}$ Simmental \times ¹/₄ Angus (CON), and 3) ¹/₂ Wagyu \times ¹/₄ Angus \times ¹/₄ Simmental (WAG). 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 an ADG that was .17 kg/d higher (P = .0001), intake 1.09 kg/d lower (P = .0001), and gain:feed ratio .013 unit better (.190 vs .177, P = .008) than PAST steers overall. Growing treatment did not affect total concentrate consumed (P = .97). The BRI steers required 31 d less than did CON steers (P = .008), and 23 d less than WAG steers (P = .05) when fed to a constant fat end point (1.1) cm). The BRI steers exhibited an ADG .16 kg/d higher (P = .0003), tended (P = .07) to have an ADG intake .49 kg/d higher, and exhibited gain:feed .01 unit better (.189 vs 180) than WAG steers. When compared with

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 that 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 $(1,000 = \text{Small}^{00}, 1,100)$ = Modest⁰⁰) (*P* = .006) than BRI steers, resulting in 19% more (P = .09) steers grading \geq Choice and 82% more (P = .03) grading \geq 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 with PAST steers. The BRI steers had less finishing days and lower daily intake compared with 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 with BRI steers.

Key Words: Beef Cattle, Weaning, Pastures

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Introduction

Economic pressures to improve production efficiency have prompted the beef cattle industry and researchers to evaluate the performance of various biological types of cattle and methods for producing cattle that result in higher quality grade. Feeding grain diets to

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cattle is generally considered to result in meat that is more tender, flavorful, and juicy than that from forage-fed cattle.

Early weaning systems have been used when available feed is of poor quality, when grazing forages with short growing seasons, when cows are milking poorly, when calves are nursing first-calf cows, 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 studies indicate that carcass composition is similar between cattle fed a grain-based diet immediately after weaning and cattle slaughtered after a period of slower growth (Ridenour et al., 1982). Other

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	Diet sequence, % (DM basis)				
Ingredients	1	2	3	4	
NH3 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	2.13	2.28	2.42	2.52	
NE _g , Mcal/kg	1.36	1.50	1.60	1.69	
0 °					

Table 1. Composition of finishing diets fed to steers

studies, however, have indicated that nutrition affects carcass composition (Dikeman et al., 1985a). 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. Indeed, 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. In yr-1, the trial was conducted from June 29, 1995, through June 13, 1996. In yr 2, it was from June 19, 1996, through June 27, 1997. A total of 74 spring-born (January to April) steers calves were early-weaned $(117 \pm 23 \text{ d})$ and fed a high-energy diet before the trial began. Steers were randomly assigned within breed type to one of two treatments. 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 \times ¼ Simmental (**BRI**, 140 \pm 34 kg), 24 ¾ Simmental \times ¼ Angus (CON, 158 ± 18 kg), and 24 ½ Wagyu \times ¹/₄ Angus \times ¹/₄ 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[®], BovEye[®] (SmithKline 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, BoviShield 4, BovEye, and Vision 7 Somnus at weaning. Steers then received boosters of the same vaccinations 3 wk later. In yr 2, following the 82-d growing period, steers were vaccinated with TSV-2 (SmithKline Beecham) and CattleMaster 4 (SmithKline Beecham), and they were treated for parasites with Ivomec.

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

 Table 2. Ingredient composition of pelleted supplement fed to steers

Ingredient	% ^a
Sovbean 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

^aDM basis.

^bContains 176 g of monensin/kg.

°Composition (per gram): ≥3,300 IU vitamin A, ≥330 IU vitamin D₂, and ≥44 IU vitamin E.

D₃, and ≥44 IU vitamin E. ^dComposition (%): NaCl (82 to 87), Fe (≥2.57), Zn (≥2.86), Mn (≥.57), Cu (≥.23), I (≥.01), Se (≥.009). orchardgrass (*Dactylis glomerata* L.) pastures through d 127 to 208. These steers were also supplemented with .91 kg of cracked corn per animal 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 benzoate; Syntex). 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 diet was gradually increased to 77%. From this time 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 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 end point (1.1 cm \pm .33 actual). Final weights and hip heights were taken. Slaughter weight was determined by dividing hot carcass weight by .61. No differences in dressing percentage were observed as a result of 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 of 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, frozen $(-20^{\circ}C)$, and stored until all steers from that respective year had been processed. The remaining portion of the longissimus (12th-rib area) was vacuum-packaged, aged at 4°C until 14 d postmortem, and 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.

Fat and water analyses were conducted on the 9-10-11 rib subsamples using the procedures described by Novakofski et al. (1989). All samples were ovendried (110° C for 24 to 48 h). Fat was extracted using an azeotropic 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, Canton, 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 at each tasting session (five total each year).

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 gastrointestinal tract (separated into reticulorumen, omasum, abomasum, and 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 were no interactions (P > .10), so the data were pooled over years. Breed means were compared (Steel and Torrie, 1980) with the following orthogonal 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 final 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 days that cattle are exposed to a high-concentrate diets. Duckett et al. (1993) found that approximately 112 d on a highconcentrate 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 harvest 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 that are fed an energydense diet soon after weaning would need to be harvested at a lighter weight than cattle that are fed on forage for a period of time prior to finishing (Lunt and Orme, 1987). This may be true for calves weaned at approximately 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 an ADG that was .85 kg/d higher (P = .0001) than PAST steers before 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 diet with calves allowed a growing period of 76 d before being placed on the finishing diet. At the end of the 76-d growing period, the steers on the high-concentrate finishing diet .28 kg/d more than the steers on the high-roughage grower diet.

The PAST steers had an ADG .12 kg/d higher (P =.008) than CONC steers after d 208. Lancaster et al. (1973) observed similar results and reported that the grower diet steers had a .18-kg advantage in ADG, which resulted in typical compensatory growth characteristics being exhibited by the steers previously fed the grower diet. The CONC steers had an ADG .17 kg/ d higher (P = .0001) overall. Oltjen et al. (1971) reported that steers fed a forage diet initially did not sufficiently out-gain steers on a continuous highconcentrate diet when both groups were on a highconcentrate 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. The CONC steers had a height change of 2.8 cm more (P = .0001) than did PAST steers before 208 d. Lancaster et al. (1973) observed similar results and suggested that structural growth occurred at a faster rate on the finishing diet than on the grower diet. However, PAST steers had a height change 2.2 cm more (P = .01) than CONC steers after 208 d. No differences (P = .44) that were 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 feed conversions that were .012 unit (gain:feed) better (P

	Growing t			
Item	Concentrate	Pasture	SEM ^b	<i>P</i> =
No. of steers	36	36		
Initial wt, kg	144	149	4	.45
Harvest wt, kg ^c	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

Table 3. Performance of	`early-weaned	l steers receiving	a high-concentrate	diet or
g	rown on past	ure before finishi	nga	

^aLeast squares means.

^bGreatest standard error of treatment means (SEM) reported.

^cCalculated as hot carcass weight/.61.

= .009) than those of 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 the results of Fox et al. (1988), who 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 because 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 an intake 1.09 kg/d lower (P = .0001) and feed conversion .01 unit better (P = .008) than PAST steers. Lancaster et al. (1973) indicated that steers on the finishing diet 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

	Growing t	reatment		
Item	Concentrate	Pasture	SEM ^b	<i>P</i> =
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 ratio ^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/steer ^d	1,816	1,814	48	.97

Table 4. Performance of early-weaned steers receiving a high-concentrate diet or
grown on pasture before finishing^a

^aLeast squares means.

^bGreatest standard error of treatment means (SEM) reported.

^cDuring finishing phase.

^dTotal concentrate, finishing, and supplement on pasture included.

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

Table 5.	Performance of	early-weaned	steers of thre	e breed	types receiv	ving a
	high-concentrate	e diet or grov	vn on pasture	before	finishing ^a	-

^aLeast squares means.

^bBRI = $\frac{34}{4}$ Angus × $\frac{14}{4}$ Simmental, CON = $\frac{34}{4}$ Simmental × $\frac{14}{4}$ Angus, WAG = $\frac{12}{2}$ Wagyu × $\frac{14}{4}$ Angus × $\frac{14}{4}$ Simmental.

 $^c Greatest$ standard error of treatment means (SEM) reported. $^d Calculated$ as hot carcass weight/.61.

heavier (P = .02) than the BRI steers at 127 d of age and 66 kg heavier at harvest (P = .0001). There were no differences (P > .31) in initial and final weights between the BRI and WAG steers.

Differences (P < .05) existed between breed types for the number of days that steers were fed the finishing diet (Table 5). The BRI steers required 31 d fewer than CON steers (P = .008), and 23 d fewer than WAG steers (P = .05) when fed to a fat-constant end point. Greene et al. (1989) found that only approximately 65 d were needed for purebred Angus steers to reach Choice grade, whereas Zinn et al.

Table 6.	Performance of	early-weaned	steers of three	e breed types	receiving a
	high-concentrate	diet or grow	n on pasture	before finishi	nga

					Р	'=
					Con	trast
		Breed ^b			BRI	BRI
Item	BRI	CON	WAG	SEM ^c	CON	WAG
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 ratio ^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/steer ^e	1,697	2,007	1,740	59	.0003	.60

^aLeast squares means.

^bBRI = $\frac{34}{4}$ Angus × $\frac{14}{4}$ Simmental, CON = $\frac{34}{4}$ Simmental × $\frac{14}{4}$ Angus, WAG = $\frac{12}{2}$ Wagyu × $\frac{14}{4}$ Angus × $\frac{14}{4}$ Simmental.

^cGreatest standard error of treatment means (SEM) reported.

^dDuring finishing phase.

eTotal concentrate, finishing, and supplement on pasture included.

(1970) reported that 210 d were necessary for purebred Hereford steers fed an 80% concentrate diet to reach Choice. The BRI steers were 44 d younger than CON (P = .0003) and 47 d younger than WAG steers (P = .0002) when harvested at a fat-constant end point (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 an ADG .19 kg/d higher (P = .0007) than WAG steers after 208 d of age. Similar results were observed for overall ADG as BRI steers exhibited an ADG .16 kg/d higher (P = .0003) than WAG steers. The results are consistent with those of 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 affected height change between BRI and WAG steers differently during the two phases. The WAG steers tended (P = .06) to have a height change that was 1.1 cm more before 208 d of age than that of BRI steers, but BRI steers had a height change of 2.5 cm more (P = .02) 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 significant (P = .13) between BRI and WAG steers between 127 and 208 d of age. However, the BRI steers had an intake .63 kg/d higher (P = .03) than WAG steers after d 208, and they tended (P = .07) to have an overall intake .49 kg/d higher.

During the first 82 d of the trial, efficiency tended (P = .09) to be .02 (gain:feed) unit 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 feed conversions .025 unit better (P = .03) than did the WAG steers from 127 to 208 d of age. The BRI steers tended to exhibit gain:feed ratios .011 unit better than WAG steers after 208 d of age (P = .06) and overall (P = .10). The findings of Lunt et al. (1993) give further evidence that Angus steers require less feed per unit of gain than Wagyu steers. These findings agree with those of Myers et al. (1998). When compared with CON steers, BRI steers consumed 310 kg less total concentrate (P = .0003). No difference (P = .60) in total concentrate consumed was observed between the BRI and WAG steers. These results are also consistent with those of Myers et al. (1999).

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 centimeters per kilogram of hot carcass weight; kidney, pelvic, and heart fat; and yield grade. Sixty-eight percent of the steers received a yield grade of 2.9 or better, having an average yield grade of 2.8. Lancaster et al. (1973) indicated that carcass traits for 205-d-old calves placed directly on a highconcentrate finishing diet were similar to those of calves allowed a growing period of 76 d before being placed on the finishing diet.

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 diet than those allowed a 76-d growing period. Dahmen et al. (1962) found that steers fed a low level of concentrates for the 1st 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 carcass weight 40 kg heavier (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; this was expected because steers were slaughtered at a constant external fat thickness as measured by ultrasound. Compared with BRI steers, CON steers measured with LMA that were 7.2 cm² larger (P = .0006). 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 unit 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; this would be expected when

Concentrate	Pasture	SEM ^b	<i>P</i> =
36	36		
298	300	5	.79
13	16	5	.67
1.16	1.17	.05	.82
75.7	76.8	1.17	.51
.26	.26	.01	.54
2.0	1.9	.1	.38
2.81	2.77	07	72
0	3	2 8	.26
66	66		.97
34	31	8	.74
1,091	1,093	15	.92
89	89	э	.95
56	38	8	.11
2	10	4	.19
	Concentrate 36 298 13 1.16 75.7 .26 2.0 2.81 0 66 34 1,091 89 56 2	Concentrate Pasture 36 36 298 300 13 16 1.16 1.17 75.7 76.8 .26 .26 2.0 1.9 2.81 2.77 0 3 66 66 34 31 1,091 1,093 89 89 56 38 2 10	$\begin{tabular}{ c c c c } \hline Concentrate & Pasture & SEM^b \\ \hline 36 & 36 & & \\ 298 & 300 & 5 & \\ 13 & 16 & 5 & \\ 1.16 & 1.17 & .05 & \\ \hline 1.16 & 1.17 & .05 & \\ \hline 75.7 & 76.8 & 1.17 & \\ .26 & .26 & .01 & \\ 2.0 & 1.9 & .1 & \\ 2.81 & 2.77 & .07 & \\ 0 & 3 & 2 & \\ 66 & 66 & 8 & \\ 34 & 31 & 8 & \\ 1.091 & 1.093 & 15 & \\ 89 & 89 & 5 & \\ 56 & 38 & 8 & \\ 2 & 10 & 4 & \\ \hline \end{tabular}$

Table 7. Carcass quality of early-weaned steers receiving a high-concentrate diet or grown on pasture before finishing^a

^aLeast squares means.

^bGreatest standard error of treatment means (SEM) reported.

^cLongissimus muscle area.

^dHot carcass weight.

^eKidney, pelvic, and heart fat. $f_{1,000} = \text{Small}^{00}$.

Table 8.	Carcass quality o	f early-weaned	steers of three	breed types i	receiving a
	high-concentrate	diet or grown	on pasture be	efore finishing ^a	

					Р	'=
					Contrast	
		Breed ^b			BRI vs	BRI vs
Item	BRI	CON	WAG	SEM ^c	CON	WAG
No. of steers	24	24	24			
Carcass wt, kg ≤250 kg, %	289 21	329 0	279 26	7 7	.0001 .01	.31 .60
External fat thickness, cm	1.19	1.13	1.17	.06	.47	.75
LMA ^d cm ² cm ² /kg HCW ^e	73.1 .26	80.3 .25	75.3 .27	1.45 .01	.0006 .09	.27 .01
Est. KPH, % ^f	1.9	1.9	2.1	.1	.72	.03
Avg. yield grade Yield Grade 1, % Yield Grade 2, %	2.86 4 58	2.81 0 64	2.70 0 76	.09 2 10	.65 .20 .66	.19 .30 .21
Yield Grade 3, %	38	36	24	10	.91	.31
≥Choice, %	83	1,073 84 24	1,139 99 60	19 7 10	.97	.000
≥Prime, %	0	34 7	11	5	.27	.11

^aLeast squares means. ^bBRI = $\frac{3}{4}$ Angus × $\frac{1}{4}$ Simmental, CON = $\frac{3}{4}$ Simmental × $\frac{1}{4}$ Angus, WAG = $\frac{1}{2}$ Wagyu × $\frac{1}{4}$ Angus × $\frac{1}{4}$ Simmental.

^cGreatest standard error of treatment means (SEM) reported.

^dLongissimus muscle area.

^aLongissinius master tree. ^eHot carcass weight. ^fKidney, pelvic, and heart fat. $g_{1,000} = \text{Small}^{00}$, 1,100 = Modest⁰⁰.

steers are slaughtered at equivalent external fat thickness end point.

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. The 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 traits 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 weights of the CON steaks were 22.63 g heavier (P = .007) than those of the BRI steers. This would be expected because CON were 66 kg heavier (P = .0001) at slaughter, had carcass weight of 40 kg heavier (P = .0001), and had LMA of 7.2 cm² larger (P = .0006). 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 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 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 had a protein percentage .58 unit higher (P = .04) than WAG steers.

Growing treatment did not have an effect 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 those of 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 highconcentrate 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.

Table 9. Steak weights, cooking traits, composition, and sensory attributes of early-weaned steers receiving a high-concentrate diet or grown on pasture before finishing^{ab}

	Growing t			
Item	Concentrate	Pasture	SEM ^c	<i>P</i> =
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

^aLeast squares means.

^bExternal fat thickness was used as a covariate (mean = 1.17 cm).

^cGreatest standard error of treatment means (SEM) reported.

^dComposition of the 9–10–11 rib.

eSensory attributes of ribeye steaks.

 $^{\rm f}$ Evaluated by a trained sensory panel on a 15- cm continuous scale; 15 = tender, juicy, no off-flavors. $^{\rm g}$ Warner-Bratzler shear, peak force.

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Table 10. Steak weights, cooking trait, composition, and sensory attributes of
early-weaned steers of three breed types receiving a high-concentrate diet or
grown on pasture before finishing ^{ab}

					Р	'=
					Con	trast
		Breed ^c			BRI vs	BRI vs
Item	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

^aLeast squares means.

^bExternal fat thickness was used as a covariate (mean = 1.17 cm).

^cBRI = $\frac{3}{4}$ Angus × $\frac{1}{4}$ Simmental, CON = $\frac{3}{4}$ Simmental × $\frac{1}{4}$ Angus, WAG = $\frac{1}{2}$ Wagyu × $\frac{1}{4}$ Angus × $\frac{1}{4}$ Simmental.

^dGreatest standard error of treatment means (SEM) reported.

^eComposition of the 9–10–11 rib.

^fSensory 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.

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 crossbreds. Dikeman and Crouse (1975) detected no differences in palatability among Hereford \times Angus, Limousin \times Angus, or Simmental \times 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.

Table 11. Digestive tract weights of early-weaned steers receiving a high-concentrate diet or grown on pasture before finishing^{ab}

	Growing t			
Item	Concentrate	Pasture	SEM ^c	<i>P</i> =
No. of steers	7	7		
Liver, % ^d	1.79	2.01	.10	.15
Heart, % ^d	.51	.53	.10	.65
Reticulorumen, % ^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

^aLeast squares means.

^bExternal fat thickness was used as a covariate (mean = 1.01 cm).

^cGreatest standard error of treatment means (SEM) reported.

^dPercentage of hot carcass weight.

^eSmall and large intestines.

^fRumen, abomasum, omasum, and small and large intestines.

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 (reticulorumen, 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 than 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 O₂ 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 of 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 (Bensadoun and Reid, 1962; Huntington, 1982) 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.

Implications

Steers placed directly on high concentrate after weaning had greater gain, lesser intake, better efficiency, were younger at slaughter, consumed the same amount of total concentrate, and had reduced liver and reticulorumen weights than steers grown on pasture before 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 with 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 with steers of British breed type in this study.

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