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Fattening performance, carcass traits and meat quality characteristics of calves sired by Charolais, Simmental and Eastern Anatolian Red sires mated to Eastern Anatolian Red dams

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Abstract

Comparisons were made among calves sired by Charolais (C), Simmental (S) and Eastern Anatolian Red (EAR) breeds of bulls for fattening, carcass and meat quality traits when mated to EAR dams. C- and S-sired calves had 43.1% and 36.4% higher daily weight gain, 44.5% and 43.9% heavier final weight in fattening, respectively. Calves produced by C sires had best feed efficiency value (6.51 vs. 7.44 and 7.22) compared to the S and EAR sire breed groups. Carcasses of C- and S-sired calves had heavier weight, higher dressing percentage and greater Longissimus dorsi (LD) muscle area than those of EAR-sired calves. USDA yield grades were lower ($P < 0.01$) for carcasses from C and S sires, and highest for carcasses from EAR calves. C-sired calves received higher ($P < 0.01$) ratings for panel tenderness score, lower shear force value and number of chews before swallow than S- and EAR-sired progeny. Overall results of the study suggested that fattening performance, carcass and meat quality characteristics might be considerably improved by using C sires in the crossbreeding program as sire breed.

Keywords: Charolais; Simmental; Eastern Anatolian Red; Sire breeds; Fattening; Carcass traits; Meat quality

1. Introduction

Eastern Anatolian Red (EAR) cattle are the most populous and dominant breed of the eastern region of Turkey, comprising approximately 21.6% of the indigenous breeds (Anon., 2001). On small farms, EAR cattle are used as draft animals and the cows are raised for milk production.

Results of the studies conducted on EAR cattle revealed that average daily weight gain in the fattening period was about 700 g, and hot carcass weight and dressing percentage ranged from 122.3 to 152.5 kg and from 53.5% to 62.2%, respectively (Bayindir, 1988; Özhan, Tüzemen, & Yanar, 2001; Ulutas, Akbulut, Tüzemen, Özlütürk, & Yalcin, 1994).

In recent years, beef production has become an increasingly important livestock industry in Turkey. Up to now, indigenous breeds were generally used for meat production purposes especially in the eastern region of Turkey. However, fattening performance including daily weight gain and feed efficiency ratio, carcass weight and meat quality characteristics of these animals were too far from satisfying demands of cattle producers and consumers.

Imported beef breeds such as Charolais (C) and Simmental (S) as sires might be considered in crossbreeding programs which will be implemented nationwide to improve fattening and carcass parameters of EAR cattle. Comparative information about fattening ability, carcass and meat quality traits of the pure EAR and F_1 crosses with C and S is not available yet. Therefore, this project was designed to evaluate daily weight gain, feed efficiency ratio, carcass traits and organoleptic properties of calves obtained from mating of EAR cows by C, S and EAR sires.

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2. Materials and methods

A total of 58 male and female calves were produced by mating of EAR, S and C sires to EAR cows. The calves were born February through March at The Eastern Anatolian Agricultural Research Institute, Erzurum, Turkey. At birth, the calves were individually identified using plastic ear tags and metal ear clips, and birth dates recorded. All calves were nursed by their dams under similar conditions. The calves were weaned at 6 months of age. After the weaning, the young animals were fed daily 1 kg concentrate and ad libitum dry hay until fattening.

The calves at about 9–10 months of age were started on fattening in a tethered barn and fed individually. The animals were adapted to the finishing diet over 2 weeks. Cattle were provided with a finishing diet consisting of dry alfalfa and concentrate. All animals had ad libitum access to concentrate and dry alfalfa during whole fattening period. Amounts of feed offered were recorded and refused feed was weighed daily. The chemical composition of the concentrate was 88.0% dry matter, 13.7% crude protein, 2.8% ether extract, 6.0% crude ash, 12.0% crude cellulose and 53.5% nitrogen free extract. Dry alfalfa contained 92.5% dry matter, 14.7% crude protein, 1.8% ether extract, 5.0% crude ash, 25.3% crude cellulose and 45.7% nitrogen free extract.

Cattle were weighed at 14 days intervals throughout the trial. On each of 2 days at the beginning and end of the fattening period, cattle were weighed after 12 h starvation. The average of weights was recorded as the initial and final weights. Information regarding average daily weight gain, feed intake and feed efficiency ratio during finishing phase were obtained. The experiment lasted for 154 days.

All cattle were conventionally slaughtered in a commercial abattoir. Immediately following slaughter, head, hide, feet, liver, lungs and heart were removed and weighed. Hot carcass weight and some carcass measurements such as carcass length, length of the round, width of the round, thoracic depth and width of the round from medial side were also determined (Öztan, 1975; Yener, Akman, & Ertugrul, 1988). After a chill period at 4 °C for 24 h, the carcasses were ribbed, scored and graded by two trained carcass evaluators (USDA, 1989). The ribbing site was at the 12th–13th rib interface. The area of Longissimus dorsi (LD) muscle crosssection, the depth of the fat at three equally spaced locations over the Longissimus dorsi muscle, and a marbling score were determined at the ribbing site. Subcutaneous fat:LD area ratio was calculated, and the quantity of kidney, heart and pelvic fat was also recorded. All carcasses were evaluated for yield grade and the retail cuts percentage was predicted by using a mathematical equation reported by Boggs and Merkel (1984).

Beef samples were only taken from LD, gluteus medius (GM) and quadriceps (Q) muscles of male cattle, and they were excised from the carcasses at 24 h postmortem. The muscle portions were cut perpendicular to the muscle fibre into two pieces and assigned for chemical and organoleptic analysis. Raw meat samples from LD, GM and Q muscles were analysed by AOAC (1980) for moisture, ether extractable lipid, crude protein and ash. Crude protein was determined as $N \times 6.25$ (Kjeldahl method).

Meat samples for sensory evaluation were cooked in a plastic bag, in a water bath at 90 °C until they reached an internal temperature of 70 °C as outlined by Yanar (1994). Cooking yield was determined by recording uncooked and cooked weights of LD, GM and Q samples used for sensory evaluation. Cooked samples were placed on a paper towel for 5 min to remove cooking drip. Cooking yield was calculated by dividing cooked weight by uncooked weight. The cooked beef samples from LD, GM and Q muscles were portioned into sections of uniform dimensions (approximately $1 \times 1 \times 1$ cm). The warm sections were selected randomly and served immediately to the panel members. Eight panellists evaluated cooked beef samples for tenderness, juiciness, flavour intensity and general acceptability on using a nine-point hedonic scale (9 = extremely tender, 1 = extremely tough; 9 = extremely juicy, 1 = extremely dry; 9 = extremely strong beef flavour, 1 = extremely weak beef flavour; 9 = extremely high general acceptability, 1 = extremely less acceptability). Number of chews before swallow was also determined by the panel members. Beef samples for mechanical assessment of tenderness were cooled to 20 °C and six cores were removed parallel to the longitudinal orientation of the muscle fibres for Warner–Bratzler Shear force (WBS) measurements (Ockerman, 1985).

Data were statistically analysed by using the GLM procedure of the SPSS program (version 10.0) (SPSS, 1998). The Duncan method was applied for comparison of subclass means when F-tests for main effects were significant. The data on the fattening performance, slaughter and carcass traits, and carcass measurements were analysed by a mathematical model that included the effect of genotype, sex, genotype and sex interaction. The data concerning the chemical composition, sensory panel, cooking yield, WBS and number of chews before swallow were statistically analysed by another model that included the effect of genotype, muscle, genotype and muscle interaction.

3. Results and discussion

Least squares means for fattening performance traits of calves sired by C, S and EAR are presented in Table 1. C- and S-sired calves (205.96 ± 5.36 and 211.97 ± 6.76

Table 1
Least squares means with standard errors for fattening performance traits of calves sired by C, S and EAR

	N	Initial weight (kg)	Final weight (kg)	Average daily weight gain (g)	Total weight gain (kg)	Feed efficiency ratio[A]
	58					
Sire breed						
		**	**	**	**	*
C	23	205.96 ± 5.36[a]	365.68 ± 8.67[a]	1037.2 ± 37.24[a]	159.72 ± 5.73[a]	6.51 ± 0.23[b]
S	16	211.97 ± 6.76[a]	364.22 ± 10.95[a]	988.6 ± 47.01[a]	152.25 ± 7.24[a]	7.44 ± 0.29[a]
EAR	19	141.42 ± 5.83[b]	253.05 ± 9.43[b]	724.7 ± 40.50[b]	111.63 ± 6.23[b]	7.22 ± 0.25[a]
Sex of calf						
		**	**	**	**	**
Male	36	199.59 ± 4.21	364.36 ± 6.81	1069.9 ± 29.24	164.77 ± 4.50	6.27 ± 0.18
Female	22	173.31 ± 5.52	290.93 ± 8.94	763.8 ± 38.37	117.62 ± 5.91	7.84 ± 0.24
Sire breed × Sex of calf						
			*	*	*	
C × Male	14	220.14 ± 6.70	404.36 ± 10.85[a]	1196.2 ± 46.59[a]	184.21 ± 7.17[a]	5.79 ± 0.29
C × Female	9	191.78 ± 8.36	327.00 ± 13.53[b]	878.1 ± 58.10[b]	135.22 ± 8.95[b]	7.23 ± 0.36
S × Male	11	230.55 ± 7.56	419.64 ± 12.24[a]	1227.8 ± 52.56[a]	189.09 ± 8.09[a]	6.18 ± 0.33
S × Female	5	193.40 ± 11.22	308.80 ± 18.15[b]	749.4 ± 77.96[b,c]	115.40 ± 12.00[b,c]	8.69 ± 0.48
EAR × Male	11	148.09 ± 7.56	269.09 ± 12.24[c]	785.5 ± 52.56[b,c]	121.00 ± 8.09[b,c]	6.83 ± 0.33
EAR × Female	8	134.75 ± 8.87	237.00 ± 14.35[c]	663.9 ± 61.63[c]	102.25 ± 9.49[c]	7.60 ± 0.38

C: Charolais, S: Simmental, EAR: Eastern Anatolian Red.
[a–c] Means followed by a different letter within a column are statistically different.
[A] Feed efficiency ratio: consumed dry matter of feed (kg)/weight gain (kg).
* $P < 0.05$.
** $P < 0.01$.

kg, respectively) at the start of the trial were heavier than EAR-sired calves (141.42 ± 5.83 kg), and the difference was statistically different ($P < 0.01$). Difference in initial weight between male and female cattle was also significant ($P < 0.01$). Sire breed also had significant ($P < 0.01$) effects on the final weight, and C- and S-sired calves averaged higher final weights (365.68 ± 8.67 and 364.22 ± 10.95 kg, respectively) than EAR-sired calves (253.05 ± 9.43 kg). Sex of the calf also had a significant ($P < 0.01$) effect on the final weight and a sire breed × sex of calf interaction was present ($P < 0.05$). Sire breed ($P < 0.01$) and sex of the calf ($P < 0.01$) effects accounted for variation observed in average daily and total weight gains during the trial. C and S crosses were larger and had faster weight gain than pure EAR calves, and C- and S-sired calves gained 48.09 and 40.62 kg more than EAR-sired calves. Similarly, faster weight gain for S and C crosses vs. Hereford × Angus crosses and for S vs. EAR-sired calves were reported by Buckley, Baker, Dickerson, and Jenkins (1990) and Ilaslan, Geliyi, and Çakir (1981), respectively. There was no significant difference in daily gains for C- and S-sired progeny, and results reported by Southgate, Cook, and Kempster (1982) and Rahnefeld, Weiss, Fredeen, Lawson, and Newman (1988) are consistent with the findings of the present study.

Breed of sires was a significant ($P < 0.05$) source of variation in feed efficiency ratio. Calves produced by C sires had best feed efficiency value (6.51 vs. 7.44 and 7.22) compared with the other sire breed groups. The result is comparable with the findings of Amer, Kemp, and Smith (1992) who reported better feed efficiency ratio of C compared with S (6.0 vs. 6.5, respectively).

Least squares means for slaughter and non-carcass components of calves sired by C, S and EAR are presented in Table 2. Hot carcasses of C and S crosses, respectively, were 53.4% and 50.0% heavier ($P < 0.01$), and dressing percentage was 4.6% and 3.0% greater ($P < 0.01$) than EAR. Similarly, heavier carcasses and greater dressed yield for S crosses vs. EAR are in agreement with Ilaslan et al. (1981). There were no significant differences between C- and S-sired calves, although the hot carcass weight and dressing percentage of C crosses were numerically greater than S-sired calves. The result is an accordance with the findings of King, Petracek, Cohen, and Guenther (1992). The lower dressing percentage of the EAR-sired progeny is due to higher head, hide, heart + lung, liver and front + hind feet weights as a percentage of slaughter weight of EAR-sired calves compared to C- and S-sired calves.

Carcasses from C and S crosses had 89% and 59.8% larger ($P < 0.01$) LD area than that of EAR-sired calves. Subcutaneous fat:LD area ratios and LD area 100 kg^{-1} carcass weight of C crosses were significantly ($P < 0.05$) different from EAR calves (Table 3). The results indicate a considerable increase of the mascularity in C crosses compared to the pure EAR calves. Similarly, King et al. (1992) reported that progeny of C sires had numerically greater LD area than S-sired calves, but the difference was not significant.

Table 2
Least squares means with standard errors for slaughter and non-carcass components from C-, S- and EAR-sired calves

	N	Live weight (kg)	Hot carcass weight (kg)	Dressing (%)	Proportions of non-carcass components (out of 100)				
					Head (%)	Hide (%)	Heart + lung (%)	Liver (%)	Front + Hind feet (%)
	55								
Sire breed									
		**	**	**	*	*	**	**	
C	23	366.56 ± 8.46[a]	212.29 ± 5.63[a]	57.81 ± 0.50[a]	3.25 ± 0.10[a]	7.09 ± 0.15[a]	1.58 ± 0.04[a]	1.27 ± 0.04[a]	1.73 ± 0.05
S	16	362.57 ± 10.67[a]	207.68 ± 7.11[a]	56.95 ± 0.63[a]	3.55 ± 0.13[a]	7.55 ± 0.19[ab]	1.50 ± 0.04[a]	1.34 ± 0.05[a]	1.77 ± 0.06
EAR	16	249.89 ± 9.97[b]	138.42 ± 6.65[b]	55.27 ± 0.59[b]	3.67 ± 0.12[b]	7.67 ± 0.18[b]	1.73 ± 0.04[b]	1.54 ± 0.05[b]	1.80 ± 0.06
Sex of calf									
		**	**	*					
Male	34	361.37 ± 6.90	208.87 ± 4.60	57.39 ± 0.41	3.54 ± 0.08	7.63 ± 0.12	1.56 ± 0.03	1.39 ± 0.03	1.76 ± 0.04
Female	21	291.31 ± 8.89	163.40 ± 5.92	55.96 ± 0.53	3.44 ± 0.11	7.24 ± 7.24	1.65 ± 0.04	1.38 ± 0.04	1.78 ± 0.05
Sire breed × Sex of calf									
		**	**	**	*				
C × Male	14	404.79 ± 10.58[a]	237.19 ± 7.05[a]	58.52 ± 0.63	3.26 ± 0.13[c]	7.27 ± 0.19	1.50 ± 0.04	1.25 ± 0.05	1.71 ± 0.06
C × Female	9	328.33 ± 13.19[b]	187.40 ± 8.79[b]	57.10 ± 0.78	3.24 ± 0.16[c]	6.91 ± 0.23	1.66 ± 0.05	1.29 ± 0.06	1.76 ± 0.08
S × Male	11	419.55 ± 11.93[a]	245.76 ± 7.95[a]	58.53 ± 0.71	3.36 ± 0.14[b,c]	7.53 ± 0.21	1.44 ± 0.05	1.34 ± 0.05	1.68 ± 0.07
S × Female	5	305.60 ± 17.70[b]	169.60 ± 11.79[b]	55.36 ± 1.05	3.75 ± 0.21[ab]	7.57 ± 0.31	1.57 ± 0.07	1.35 ± 0.08	1.86 ± 0.10
EAR × Male	9	259.78 ± 13.19[c]	143.64 ± 8.79[c]	55.11 ± 0.78	3.99 ± 0.16[a]	8.09 ± 0.23	1.73 ± 0.05	1.59 ± 0.06	1.88 ± 0.08
EAR × Female	7	240.00 ± 14.96[c]	133.20 ± 9.97[c]	55.43 ± 0.89	3.34 ± 0.18[b,c]	7.26 ± 0.27	1.73 ± 0.06	1.50 ± 0.07	1.72 ± 0.09

C: Charolais, S: Simmental, EAR: Eastern Anatolian Red.
[a–c] Means followed by a different letter within a column are statistically different.
[*] $P < 0.05$.
[**] $P < 0.01$.

Table 3
Least squares means with standard errors for carcass characteristics

	N	Fat thickness over LD[A] (mm)	LD[A] area (cm^2)	LD area 100 kg^{-1} carcass weight (cm^2)	Marbling score	Pelvic fat (kg)	Kidney fat (kg)	KPH fat (%)	USDA Yield grade	Retail cuts (%)	Subcutaneous fat:LD area ratio
	38										
Sire breed											
			**	*				**	**	**	*
C	18	5.60 ± 0.40	76.32 ± 3.90[a]	34.68 ± 1.26[a]	13.46 ± 0.44	6.11 ± 0.34	0.31 ± 0.01	2.93 ± 0.17[b]	1.69 ± 0.18[b]	52.98 ± 0.41[a]	24.89 ± 2.40[a]
S	10	6.42 ± 0.58	64.37 ± 5.57[a]	30.03 ± 1.79[b]	14.21 ± 0.63	6.19 ± 0.48	0.34 ± 0.02	3.26 ± 0.24[b]	2.35 ± 0.26[b]	51.45 ± 0.59[a]	33.47 ± 3.42[a,b]
EAR	10	5.58 ± 0.54	40.29 ± 5.21[b]	29.38 ± 1.68[b]	13.23 ± 0.59	5.90 ± 0.45	0.29 ± 0.02	4.50 ± 0.22[a]	3.10 ± 0.24[a]	49.78 ± 0.55[b]	34.13 ± 3.20[b]
Sex of calf											
			**	*	*	*	**	**	**	**	**
Male	24	5.40 ± 0.35	72.32 ± 3.40	33.25 ± 1.10	12.88 ± 0.39	5.51 ± 0.30	0.35 ± 0.01	2.82 ± 0.15	1.81 ± 0.16	52.69 ± 0.36	25.29 ± 2.09
Female	14	6.34 ± 0.48	48.34 ± 4.58	29.47 ± 1.48	14.39 ± 0.52	6.62 ± 0.40	0.28 ± 0.01	4.31 ± 0.20	2.95 ± 0.21	50.13 ± 0.48	36.37 ± 2.82
Sire breed × Sex of calf											
C × Male	11	4.77 ± 0.50	90.22 ± 4.87	37.51 ± 1.57	12.14 ± 0.55	5.61 ± 0.42	0.34 ± 0.02	2.42 ± 0.21	1.00 ± 0.22	54.54 ± 0.51	18.68 ± 2.99
C × Female	7	5.50 ± 0.63	80.99 ± 6.10	30.87 ± 1.97	13.43 ± 0.69	5.57 ± 0.53	0.37 ± 0.02	2.29 ± 0.26	1.64 ± 0.28	53.04 ± 0.64	23.52 ± 3.75
S × Male	6	5.92 ± 0.68	45.74 ± 6.59	31.37 ± 2.12	13.08 ± 0.75	5.33 ± 0.57	0.33 ± 0.02	3.75 ± 0.28	2.79 ± 0.30	50.49 ± 0.69	33.68 ± 4.05
S × Female	7	6.43 ± 0.63	62.41 ± 6.10	31.84 ± 1.97	14.79 ± 0.69	6.61 ± 0.53	0.28 ± 0.02	3.45 ± 0.26	2.37 ± 0.28	51.42 ± 0.64	31.11 ± 3.75
EAR × Male	3	7.33 ± 0.97	47.76 ± 9.32	29.18 ± 3.00	15.00 ± 1.06	6.80 ± 0.81	0.30 ± 0.03	4.24 ± 0.40	3.06 ± 0.43	49.86 ± 0.98	43.42 ± 5.73
EAR × Female	4	5.25 ± 0.84	34.84 ± 8.07	27.39 ± 2.60	13.38 ± 0.92	6.46 ± 0.70	0.26 ± 0.02	5.25 ± 0.35	3.41 ± 0.37	49.10 ± 0.85	34.58 ± 4.96

C: Charolais, S: Simmental, EAR: Eastern anatolian red.
[a,b] Means followed by a different letter within a column are statistically different.
[A] LD: Longissimus dorsi.
* $P < 0.05$.
** $P < 0.01$.

Table 4
Least squares means with standard errors for carcass measurements

	N	Carcass length (cm)	Length of the round (cm)	Thoracic depth (cm)	Width of the round (cm)	Width of the round from medial side (cm)
	55					
Sire breed						
		**			**	**
C	23	156.64 ± 3.45[a]	68.31 ± 1.92	57.96 ± 2.03	41.04 ± 0.89[a]	20.74 ± 0.56[a]
S	16	153.36 ± 4.36[a]	65.20 ± 2.43	56.16 ± 2.57	38.68 ± 1.12[a]	20.89 ± 0.70[a]
EAR	16	139.64 ± 4.07[b]	61.57 ± 2.27	51.86 ± 2.40	35.98 ± 1.05[b]	17.99 ± 0.66[b]
Sex of calf						
		**			**	**
Male	34	156.07 ± 2.82	66.76 ± 1.57	56.62 ± 1.66	40.44 ± 0.73	20.96 ± 0.45
Female	21	143.70 ± 3.63	63.29 ± 2.02	54.03 ± 2.14	36.69 ± 0.94	18.79 ± 0.59
Sire breed × Sex of calf						
C × Male	14	161.29 ± 4.32	69.29 ± 2.41	60.14 ± 2.54	42.86 ± 1.11	22.14 ± 0.70
C × Female	9	152.00 ± 5.39	67.33 ± 3.00	55.78 ± 3.17	39.22 ± 1.39	19.33 ± 0.87
S × Male	11	163.91 ± 4.87	68.00 ± 2.71	57.73 ± 2.87	41.36 ± 1.26	22.18 ± 0.79
S × Female	5	142.80 ± 7.23	62.40 ± 4.02	54.60 ± 4.26	36.00 ± 1.86	19.60 ± 1.17
EAR × Male	9	143.00 ± 5.39	63.00 ± 3.00	52.00 ± 3.17	37.11 ± 1.39	18.56 ± 0.87
EAR × Female	7	136.29 ± 6.11	60.14 ± 3.40	51.71 ± 3.60	34.86 ± 1.57	17.43 ± 0.99

C: Charolais, S: Simmental, EAR: Eastern anatolian red.
[a,b] Means followed by a different letter within a column are statistically different.
** $P < 0.01$.

Table 5
Least squares means with standard errors for chemical analysis of LD, GM and Q muscles

	N	Moisture (%)	Fat (%)	Ash (%)	Protein (%)	Cooking yield (%)
	18					
Sire breed						
		*	**		*	
C	8	75.60 ± 0.46[a]	1.66 ± 0.34[a]	1.17 ± 0.02	20.46 ± 0.18[a]	70.97 ± 1.49
S	5	74.95 ± 0.58[a,b]	1.66 ± 0.43[a]	1.20 ± 0.02	21.24 ± 0.23[b]	74.95 ± 1.89
EAR	5	73.63 ± 0.58[b]	3.38 ± 0.43[b]	1.18 ± 0.02	21.00 ± 0.23[a,b]	69.89 ± 1.89
Muscle						
			**	**		
LD	18	73.98 ± 0.54	3.56 ± 0.41[b]	1.18 ± 0.02[a,b]	20.96 ± 0.22	74.39 ± 1.77
GM	18	74.47 ± 0.54	1.41 ± 0.41[a]	1.23 ± 0.02[a]	20.93 ± 0.22	72.04 ± 1.77
Q	18	75.74 ± 0.54	1.73 ± 0.41[a]	1.13 ± 0.02[b]	20.81 ± 0.22	69.38 ± 1.77
Sire breed × Muscle						
C × LD	8	75.47 ± 0.79	2.40 ± 0.59	1.17 ± 0.03	20.39 ± 0.32	73.28 ± 2.58
C × GM	8	75.68 ± 0.79	1.06 ± 0.59	1.17 ± 0.03	20.03 ± 0.32	72.67 ± 2.58
C × Q	8	75.66 ± 0.79	1.51 ± 0.59	1.16 ± 0.03	20.97 ± 0.32	66.96 ± 2.58
S × LD	5	74.46 ± 1.00	2.39 ± 0.75	1.23 ± 0.04	21.59 ± 0.40	75.87 ± 3.27
S × GM	5	74.35 ± 1.00	1.18 ± 0.75	1.26 ± 0.04	21.58 ± 0.40	73.96 ± 3.27
S × Q	5	76.05 ± 1.00	1.41 ± 0.75	1.12 ± 0.04	20.55 ± 0.40	75.01 ± 3.27
EAR × LD	5	72.02 ± 1.00	5.89 ± 0.75	1.15 ± 0.04	20.89 ± 0.40	74.02 ± 3.27
EAR × GM	5	73.38 ± 1.00	1.99 ± 0.75	1.25 ± 0.04	21.19 ± 0.40	69.50 ± 3.27
EAR × Q	5	75.50 ± 1.00	2.25 ± 0.75	1.12 ± 0.04	20.92 ± 0.40	66.16 ± 3.27

C: Charolais, S: Simmental, EAR: Eastern anatolian red, LD: Longissimus dorsi, GM: Gluteus medius, Q: Quadriceps.
[a–c] Means followed by a different letter within a column are statistically different.
* $P < 0.05$.
** $P < 0.01$.

Comparing measurements of fatness, such as average fat thickness over LD muscle, amount of pelvic and kidney fat and marbling scores, indicated no significant differences among the sire groups (Table 3). However, percentage of kidney, pelvic and heart (KPH) fat was significantly ($P < 0.01$) affected by sire breeds, and C and S crosses had lower percentage of KPH fat compared to purebred EAR calves. Fat depth over LD muscle of C-sired calves was less than S, but was not statistically significant. The result is supported by Amer

Table 6
Least squares means with standard error for sensory panel scores, number of chews before swallow and WBS[A]

	N	Tenderness	Juiciness	Flavour	Acceptability	NCBS[A]	WBS[B]
	18						
Sire breed							
		**		**	**	**	**
C	8	6.69 ± 0.24^{a}	5.96 ± 0.18	6.09 ± 0.13^{a}	6.29 ± 0.12^{a}	33.28 ± 1.53^{a}	8.03 ± 0.76^{a}
S	5	5.44 ± 0.30^{b}	5.75 ± 0.23	5.32 ± 0.16^{b}	5.41 ± 0.15^{b}	38.93 ± 1.46^{b}	11.05 ± 0.70^{b}
EAR	5	5.72 ± 0.29^{b}	5.62 ± 0.23	6.06 ± 0.16^{a}	6.02 ± 0.15^{a}	37.68 ± 1.46^{b}	11.49 ± 0.96^{b}
Muscle							
LD	18	6.45 ± 0.28	6.13 ± 0.21	6.04 ± 0.15	6.19 ± 0.14	34.64 ± 1.37	10.24 ± 0.90
GM	18	5.66 ± 0.28	5.63 ± 0.21	5.68 ± 0.15	5.75 ± 0.14	38.23 ± 1.37	10.38 ± 0.90
Q	18	5.73 ± 0.28	5.56 ± 0.21	5.76 ± 0.15	5.79 ± 0.14	37.01 ± 1.37	9.95 ± 0.90
Sire breed × Muscle							
						*	
C × LD	8	7.51 ± 0.41	6.28 ± 0.31	6.38 ± 0.22	6.74 ± 0.21	29.38 ± 2.00^{c}	7.14 ± 1.32
C × GM	8	6.83 ± 0.41	5.99 ± 0.31	6.11 ± 0.22	6.32 ± 0.21	$33.16 \pm 2.00^{b,c}$	7.66 ± 1.32
C × Q	8	5.72 ± 0.41	5.61 ± 0.31	5.78 ± 0.22	5.80 ± 0.21	$37.30 \pm 2.00^{a,b}$	9.29 ± 1.32
S × LD	5	5.37 ± 0.52	5.97 ± 0.40	5.43 ± 0.28	5.44 ± 0.26	41.08 ± 2.53^{a}	13.77 ± 1.66
S × GM	5	4.98 ± 0.52	5.59 ± 0.40	5.10 ± 0.28	5.24 ± 0.26	$40.53 \pm 2.53^{a,b}$	11.21 ± 1.66
S × Q	5	5.98 ± 0.52	5.70 ± 0.40	5.44 ± 0.28	5.57 ± 0.26	$35.17 \pm 2.53^{a\ c}$	8.16 ± 1.66
EAR × LD	5	6.48 ± 0.52	6.15 ± 0.40	6.30 ± 0.28	6.39 ± 0.26	$33.48 \pm 2.53^{b,c}$	9.80 ± 1.66
EAR × GM	5	5.18 ± 0.52	5.33 ± 0.40	5.83 ± 0.28	5.68 ± 0.26	41.00 ± 2.53^{a}	12.26 ± 1.66
EAR × Q	5	5.50 ± 0.52	5.38 ± 0.40	6.05 ± 0.28	6.00 ± 0.26	$38.55 \pm 2.53^{a,b}$	12.40 ± 1.66

C: Charolais, S: Simmental, EAR: Eastern anatolian red.
[a–c] Means followed by a different letter within a column are statistically different.
[A] NCBS: Number of chews before swallow.
[B] Warner bratzler shear.
* $P < 0.05$.
** $P < 0.01$.

et al. (1992), Newman et al. (1994) and Rahnefeld, Fredeen, Weiss, Lawson, and Newman (1983) who indicated a trend toward less subcutaneous fat thickness of C-sired calves than that of S-sired calves.

The progeny of C and S sires also had higher ($P < 0.01$) cutability than EAR-sired calves (Table 3). Carcasses from C and S crosses had 3.20 % and 1.67% higher ($P < 0.01$) cutability values than that of EAR-sired calves. Cutability estimates did not differ between C and S sire breeds as reported by King et al. (1992) and Newman et al. (1994).

Most of the carcass measurements except for length of the round and thoracic depth were affected by sire breeds. C- and S-sired progeny had significantly higher ($P < 0.01$) carcass length, width of the round and width of the round from medial side measurements than those of progeny of EAR sires (Table 4). For carcass length, width of the round and width of the round from medial side, C- and S-sired calves exceeded EAR-sired progeny by 12.2%, 14.1%, 15.3%, and 9.8%, 7.5%, 16.1%, respectively.

The carcasses from calves by C sires were higher in water ($P < 0.05$) and lower in fat ($P < 0.01$) content than those from purebred EAR calves (Table 5). The result followed the same trend as measures of fatness in the carcass composition data. Type of muscle had a significant ($P < 0.01$) effect on the percentages of fat and ash content. The fat content of LD muscle was significantly higher ($P < 0.01$) than GM and Q muscles. In general, the values concerning chemical composition were found to be within the range of the findings by Buckley et al. (1990) and Gariepy, Seoane, Cloteau, Martin, and Roy (1999).

Sire breed was a significant ($P < 0.01$) source of variation in Warner–Bratzler Shear force (WBS), sensory panel ratings for tenderness, flavour intensity, general acceptability and number of chews before swallow (Table 6). C-sired calves received higher ($P < 0.01$) ratings for panel tenderness score, lower ($P < 0.01$) WBS value and number of chews before swallow than S- and EAR-sired progeny. Flavour intensity and general acceptability of calves sired by C and EAR were better than those of S-sired progeny.

4. Conclusion

The present study illustrated that there were several differences between calves sired by C, S and EAR in terms of fattening, carcass and meat quality traits. C-sired calves provided the most desirable combination of fattening and carcass as well as meat quality traits. Therefore, C sires might be suggested for mating with EAR cattle in the crossbreeding programs which will be implemented in Turkey.

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