Fattening Performance, Carcass Characteristics and Beef Quality of Holstein–Friesian, Brown–Swiss and Simmental Bulls

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Abstract: In this study, the fattening performance, carcass characteristics and beef quality of Holstein–Friesian (HF), Brown Swiss (BS) and Simmental (SIM) bulls were determined. For this aim, 10 HF and 8 BS in the first and 7 HF and 10 SIM in the second group were used. The values of HF and BS bulls in the first group were determined 549.20±16.87 and 512.62±16.86 kg for final weight (FW), 1.34±0.05 and 1.35±0.06 kg for average daily gain (ADG), 52.51±0.59 and 54.40±0.66% for dressing percentage (DP), 279.44±3.28 and 289.40±3.69 kg for hot carcass weight (HCW), 66.82±2.83 and 82.76±3.17 cm^2 for rib eye area (REA), 0.23±0.03 and 0.29±0.03 cm for subcutaneous fat thickness (SFT), 5.92±0.02 and 5.94±0.02 for pH24, 25.10±1.77 and 25.87±1.98% for cooking loss (CL) and 40.21±7.64 and 53.54±8.55 N for shear force (SF). On the other hand, the averages of HF and SIM bulls in the second group were found 579.14±16.60 and 562.00±13.88 kg for FW, 1.57±0.05 and 1.62±0.04 kg for ADG, 53.47±0.72 and 54.29±0.60% for DP, 304.36±4.14 and 309.25±3.45 kg for HCW, 69.50±4.10 and 76.50±3.43 cm^2 for REA, 0.49±0.08 and 0.36±0.07 cm for SFT, 5.74±0.04 and 5.77±0.04 for pH24, 26.63±1.10 and 27.09±0.92% for CL and 40.89±4.56 and 60.67±3.81 N for SF. Under the same managerial and nutritional conditions, fattening performance of HF was similar to BS and SIM breeds, but DP and REA of BS were higher, and beef from SIM was firmer that those of HF.

Keywords: average daily gain, dressing percentage, cold carcass weight, rib eye area, shear force

Siyah–Alaca, Esmer ve Simmental Tosunların Besi Performansı, Karkas ve Et Kalite Özellikleri

Özet: *Bu çalışmada, Siyah–Alaca (SA), Esmer (ES) ve Simmental (SIM) tosunların besi performansı, karkas ve et kalitesi belirlenmiştir. Bu amaçla, ilk grupta 10 SA ve 8 ES ve ikinci grupta 7 SA ve 10 SIM tosun kullanılmıştır. SA ve ES'nin bulunduğu ilk grupta sırasıyla; besi sonu ağırlığı (BSA) 549.20±16.87 ve 512.62±16.86 kg, günlük canlı ağırlık artışı (GCAA) 1.34±0.05 ve 1.35±0.06 kg, karkas randımanı (KR) %52.51±0.59 ve 54.40±0.66, sıcak karkas ağırlığı (SKA) 279.44±3.28 ve 289.40±3.69 kg, göz kası alanı (GKA) 66.82±2.83 ve 82.76±3.17 cm^2, sırt yağı kalınlığı (SYK) 0.23±0.03 ve 0.29±0.03 cm, pH24 5.92±0.02 ve 5.94±0.02, pişirme kaybı (PK) %25.10±1.77 ve 25.87±1.98 ve kesme kuvveti (KK) 40.21±7.64 ve 53.54±8.55 N olarak tespit edilmiştir. Diğer yandan, SA ve SIM'in bulunduğu ikinci grupta ise sırasıyla; BSA 579.14±16.60 ve 562.00±13.88 kg, GCAA 1.57±0.05 ve 1.62±0.04 kg, KR %53.47±0.72 ve 54.29±0.60, SKA 304.36±4.14 ve 309.25±3.45 kg, GKA 69.50±4.10 ve 76.50±3.43 cm^2, SYK 0.49±0.08 ve 0.36±0.07 cm, pH24 5.74±0.04 ve 5.77±0.04, PK %26.63±1.10 ve 27.09±0.92, ve KK 40.89±4.56 ve 60.67±3.81 N olarak bulunmuştur. Aynı çevre ve besleme şartlar altında, SA ırkı tosunların besi performansı ES ve SIM ırkı ile benzer, ama KR ve GKA ES'den yüksektir. SIM ırkının ise eti SA'dan daha sert bulunmuştur.*

Anahtar Kelimeler: *günlük canlı ağırlık artışı, karkas randımanı, soğuk karkas ağırlığı, göz kası alanı, kesme kuvveti*

INTRODUCTION

The demand for the amount and also good quality of meat has increased. The quality of meat is determined by the chemical, biochemical and physical properties of pre and post mortem muscle. The most important components of beef quality are leanness, tenderness and flavor (Valin *et al*., 1992). The complex concept of meat quality was emphasized and the quality of meat was divided into intrinsic and extrinsic quality traits (Hocquette *et al*., 2012). Nowadays, in addition to its taste and convenience, besides the price, safety and healthiness of the meat become very important criteria (Williams, 2008; Hocquette *et al*., 2012).

As the nutritional value depends on the protein and fat content of the muscle, color, tenderness, texture, marbling and water holding capacity are the main beef quality criteria for the consumers (Pogorzelska *et al*., 2012). It was highlighted that, in purchasing, sensory factors like color and fat, but in consuming, texture and flavor are the main factors affecting the consumer appreciation of the product (Williams, 2008).

All of the factors mentioned above are affected by management, rate of growth, breed, slaughter age, nutritional status, sex, duration of finishing period, finishing weight and pre– and post–slaughtering conditions (Dannenberger *et al*., 2006; Ozluturk *et al*., 2008; Williams, 2008; Marencic *et al*., 2012).

There were some researches about the fattening performances (Tüzemen *et al*., 1990; Akbulut and Tüzemen, 1994; Pichler and Frickh, 2000; Sami *et al*., 2004; Aslan and Zülkadir, 2009), slaughtering and carcass characteristics (Karakaş, 2002; Koç and Akman, 2003; Önenç, 2003; Sağöz *et al*., 2005) and beef quality traits (Dannenberger *et al*., 2006; Yüksel *et al*., 2009; Kahraman *et al*., 2011; Marencic *et al*., 2012) of Holstein Friesian (HF), Brown Swiss (BS) and Simmental (SIM) bulls.

HF is a widely–used breed for milk production in the world and also in Turkey. The males of this breed are also mainly used for beef production. About 78% of the European breeds in Turkey is HF and other European breeds raised in Turkey are SIM, BS and Jersey. In recent years, in addition to SIM, some beef cattle breeds, such as Angus, Hereford, Charolaise, and Limousine are also imported to increase the beef production in Turkey. However, studies on fattening, carcass and beef quality traits of these breeds were limited. In this study, it was aimed to compare the fattening performance, slaughtering and carcass characteristics and beef quality traits of HF with BS and SIM bulls.

MATERIALS and METHODS

The study was carried out at a fattening farm located in Efeler district, in Aydin province, Turkey. The geographic coordinates of the farm are E28°04'9.12'' and N37°46'55.2''.

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Animal materials

In the study, 17 heads of HF, 10 heads of SIM and 8 heads of BS bulls were obtained from the fattening farm, close by dairy farms and also nearest livestock markets. The animals were divided into two groups and fed in two paddocks. In the first group 10 heads of HF and 8 heads of BS, in the second groups 7 heads of HF and 10 heads of SIM were fattened. The surface of each paddock was 120 m^2 (15 m x 8 m). The fattening period in the first and second groups were 148 days and 177 days, respectively. After about 12 hours of fasting, the animals were weighed monthly in the morning (08:00–10:00). After 30 days for adaptation period to feed, the averages weight of the animals in the first three days of fattening were accepted as the initial weight (IW). Feed conversion ratios (FCR) of the groups were calculated by dividing the total consumption of total mixed ration (TMR) into total weight gain during the fattening. For the first group, IW of HF and BS were 347.17±9.80 kg and 319.80±10.96 kg (P>0.05), respectively. For the second group, IW of HF and SIM were 307.24±14.28 kg and 292.36±11.95 kg (P>0.05), respectively.

Feeding

During the fattening period, water and salt rocks in the banker and ration containing wheat straw, tomato meal (24% DM), barley flakes, and mixed feeds were provided ad libitum. The ration fed to the groups and the time of feeding is shown in Table 1. The calculated nutrient components of the feeds are shown in Table 2. The rations 1–4 were fed as TMR. During the last 67 days in the first group and 79 days in the second group, the tomato meal was not given (the ration 5 and 6).

Slaughtering, carcass and beef quality

The animals were slaughtered in an commercial abattoir, 25 km away from the farm. After the transportation of the animals, bulls were let to rest about 1–2 hours, and then were slaughtered. In the slaughtering, the rules of Slaughtering Regulation No:37 of Turkish Meat and Milk Authority were followed.

After slaughtering, carcasses were weighted, bisected and stored +4°C for 24 hours. Then, cold carcass weight (CCW), dressing percentage (DP), drip loss (DL), pH, rib eye area (REA) between 12–13 ribs, and subcutaneous fat thickness (SFT) were determined on the next day. The pH's of carcasses was measured with pH meter (HANNA HI 99163). SFT was measured with a composing stick. The grid procedure (Boggs and Merkel, 1984) was used for the determination of REA by taking the images of the samples with a camera. The color coordinates (L*, a* and b*), cooking loss (CL, %) and Warner Bratzler shear force (WBSF, N) were also determined from the eye muscle (Honikel, 1998).

Statistical analysis

The data were analyzed using PROC MIXED procedure of SAS (1999). Because of slaughtering the first group was about one month earlier than the second group, the data of two groups were analyzed separately. The differences between least square means of the fixed factors levels were considered to be statistically significant at P<0.05 (2–tailed) based on Tukey's adjustment type I error rate. The statistical models used for the analysis are given in Equation 1 (for IW and FW), Equation 2 (for average daily gain, ADG) and Equation 3 (for carcass and beef quality traits) as follows:

$$Y_{ij} = \mu + a_i + e_{ij} \quad (1)$$
$$Y_{ijk} = \mu + a_i + d_j + (ad)_{ij} + b(X_{ij} - \overline{X}) + e_{ijk} \quad (2)$$
$$Y_{ij} = \mu + a_i + b(X_i - \overline{X}) + e_{ij} \quad (3)$$

where is μ the overall mean, Y_{ij} is the observation of IW, FW, carcass and beef quality traits, Y_{ijk} is the observation of ADG and a_i is breed effects (i= HF or BS for the first group, i= HF or SIM for the second group), b represents the regression coefficient of IW on ADG, or the regression coefficient of FW on carcass characteristics, or the regression coefficient of CCW on beef quality traits, d_j is period effects (j= 1, 2, 3, 4 and 5 for the first group, j= 1, 2, 3, 4, 5 and 6 for the second group), $(ad)_{ij}$ is breed x period interaction effects, $\overline{X}$ is the average IW for ADG analysis, or the average FW for slaughtering and carcass traits analysis, and the average CCW for beef quality traits analysis, X_{ij} is ADG, X_i is FW for slaughtering and carcass traits, and the CCW for beef quality traits, e_{ij} and e_{ijk} are the residual random errors.

RESULTS and DISCUSSION

Fattening performance

IW, FW and FCR means in Group I were 347.17±9.80 kg, 549.20±16.87 kg and 7.37 kg for HF and 319.80±10.96 kg, 512.62±16.86 kg and 7.35 kg for BS, respectively. For Group II, the means for the same traits were 307.24±14.28 kg, 579.14±16.60 kg and 6.15 kg for HF and 292.36±11.95 kg, 562.00±13.88 kg and 6.21 kg for SIM, respectively (Table 3). The effects of period and breed x period interaction on ADG were found to be statistically significant for both groups. The effect of IW on ADG was found to be statistically significant (P<0.05) for Group I but, its effect on ADG was statistically insignificant (P>0.05) for Group II. The effects of breed

Table 1. Amounts of feeds given to the groups (kg/animal) and feeding period

	Days 1.Group	Days 2.Group	Wheat Straw	Tomato meal (24% DM)	Barley flakes	Concentrate
Ration1	-	29	1.5	7	4	2
Ration2	29	30	1.5	7	4.8	2
Ration3	30	22	1.5	7	5.25	2.5
Ration4	22	17	1.3	7	5.5	2.5
Ration5	32	28	2	-	6.5	3.25
Ration6	35	51	1.5	-	7	3.5

Table 2. Nutrient components of the feeds and ration

	DM (%)	Ash (%)	Ether excreta (%)	CP (%)	NDIN	ADIN	NDF (%)	ADF (%)	ADL (%)	ME (MCal/kg)
Dried tomato meal	93.6	5.3	7.7	16.7	-	-	53.2	52.4	-	-
Concentrate	94.1	8.5	5.8	17.5	-	-	34.7	16.1	-	-
Barley flakes	92.6	3.1	2.2	11.0	-	-	21.1	6.7	-	-
Ration 1	93.7	6.4	5.1	11.3	5.7	3.7	42.8	29.7	8.6	2.13
Ration 2	93.4	5.5	3.0	12.6	7.6	5.0	34.6	20.8	6.2	2.23
Ration 3	93.6	5.8	4.4	12.6	7.6	5.0	34.6	20.8	6.2	2.41
Ration 4	93.4	4.7	3.1	12.5	7.4	4.9	33.3	20.0	6.0	2.32

DM: Dry matter, CP: Crude Protein, NDIN: Neutral detergent insoluble nitrogen, ADIN: Acid detergent insoluble nitrogen, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin, ME: Metabolizable energy.

Table 3. Initial (IW) and final (FW) weights and feed conversion ratio (FCR, dry matter intake, kg/1 kg ADG) of HF, BS and SIM bulls

Breed	n	Fattening period (day)	IW (kg)	FW (kg)	FCR
Group I			NS	NS	
HF	10	148	347.17±9.80	549.20±16.87	7.37
BS	8	148	319.80±10.96	512.62±16.86	7.35
Group II			NS	NS	
HF	7	177	307.24±14.28	579.14±16.60	6.15
SIM	10	177	292.36±11.95	562.00±13.88	6.21

NS: Not significant, HF: Holstein–Friesian, BS: Brown–Swiss, SIM: Simmental.

on ADG in both groups was also found to be statistically insignificant (P>0.05). ADG means for HF and BS in the first group and HF and SIM in the second group were determined to be 1.34±0.05 and 1.35±0.05 kg, and 1.57±0.05 and 1.62±0.04 kg, respectively (Table 4).

FCR found for HF (7.37 kg) and BS (7.35 kg) in Group I were higher than the results of previous studies (Tüzemen *et al.*, 1990; Akbulut and Tüzemen, 1994; Yanar *et al.*, 1990; Özdoğan, 2007), but lower than Yüksel *et al.* (2009) and similar to Sağöz *et al.* (2005). FCR found for HF (6.15 kg) and SIM (6.21 kg) breeds in Group II were also lower than some previous studies (Başaran and Akcan, 1997; Başpınar *et al.*, 1999; Karakas, 2002; Sami *et al.*, 2004), higher than the results reported for HF (Akbulut and Tüzemen, 1994) and also similar to the results reported for SIM (Tüzemen *et al.*, 1990; Akbulut and Tüzemen, 1994).

ADG found in this study for BS (1.35±0.06 kg) was lower than Özdoğan (2007), but higher than Yanar *et al.* (1990) and Sağöz *et al.* (2005). For HF in Group I, ADW (1.34±0.05 kg) found in this study was similar to some earlier reports (Yüksel *et al.*, 2009; Kahraman *et al.*, 2011), but higher than the results by Başaran and Akcan (1997), Başpınar *et al.* (1999), Koç and Akman (2003). For the second group, ADG found for HF (1.57±0.05 kg) and SIM (1.62±0.04 kg) breeds were higher than the results of earlier reports (Başpınar *et al.*, 1999; Pichler and Frickh, 2000; Karakas, 2002; Koç and Akman, 2003; Sami *et al.*, 2004; Dannenberger *et al.*, 2006; Aslan and Zülkadir, 2009).

The fattening performances of HF and BS in Group I are in agreement with the literature, however, the performances of HF and SIM in Group II are generally higher than the earlier reports. A better performance obtained in this study for the second group than that of the first group could be attributed to lighter IW and longer fattening period of this group.

Carcass characteristics and beef quality

Except for DP, in the first group, breed effects for other traits were found statistically insignificant (Table 5). The effects of slaughtering weight on HCW and CCW in both groups and on DP in the first and DL in the second group were detected to be statistically significant (P<0.05).

The average HCW, DP, CCW and DL for HF and BS in the first group were 279.44±3.28 kg and 289.40±3.69 kg (P>0.05), 52.51±0.59% and 54.40±0.66% (P<0.05), 274.52±3.21 kg and 284.10±3.61 kg (P>0.05), and 1.76±0.04% and 1.83±0.04% (P>0.05), respectively. The means of the same traits for HF and SIM in the second group were 304.36±4.14 kg and 309.25±3.45 kg, 53.47±0.72% and 54.29±0.60%, 299.19±4.04 kg and 303.99±3.37 kg, and 1.70±0.05% and 1.70±0.05%, respectively (Table 5).

HCW found in this study for HF in both groups and for BS are higher than some earlier reports (Alpan, 1972; Yanar *et al.*, 1990; Başaran and Akcan, 1997; Koç and Akman, 2003; Sağöz *et al.*, 2005), but the means found for HF (279.44±3.28

Table 5. Hot (HCW) and cold (CCW) carcass weights (kg), dressing percentage (DP, %) and drip loss (DL %) for HF, BS and SIM bulls

Breed	n	HCW	DP	CCW	DL
Group I		NS	*	NS	NS
HF	10	279.44±3.28	52.51±0.59	274.52±3.21	1.76±0.04
BS	8	289.40±3.69	54.40±0.66	284.10±3.61	1.83±0.04
Slau. Weight		**	NS	**	NS
Group II		NS	NS	NS	NS
HF	7	304.36±4.14	53.47±0.72	299.19±4.04	1.70±0.05
SIM	10	309.25±3.45	54.29±0.60	303.99±3.37	1.70±0.05
Slau. Weight		**	NS	**	*

NS: Not significant, * P<0.05, ** P<0.01, HF: Holstein–Friesian, BS: Brown–Swiss, SIM: Simmental

Table 4. LS MEANS and standard errors of ADG for HF, BS and SIM bulls

Group I

Factor	n	Day	ADG (kg)
			NS
HF	10	148	1.34±0.05
BS	8	148	1.35±0.06
Period			**
1		29	1.86 ± 0.08^{Aa}
2		30	1.58 ± 0.08^{ABac}
3	18	22	1.07 ± 0.08^{BCb}
4		32	1.44 ± 0.08^{Bc}
5		35	0.79 ± 0.08^{Cb}
6		-	-
Breed x Period			*
HF1		29	1.75 ± 0.11^{Aa}
HF2		30	1.79 ± 0.11^{Aa}
HF3		22	1.03 ± 0.11^{BCb}
HF4	10	32	1.51 ± 0.11^{ABab}
HF5		35	0.74 ± 0.11^{Ccb}
-		-	-
BS1		29	1.94 ± 0.22^{Aa}
BS2		30	1.33 ± 0.22^{ABb}
BS3	8	22	1.10 ± 0.22^{Bb}
BS4		32	1.35 ± 0.22^{ABb}
BS5		35	0.83 ± 0.22^{Bb}
-		-	-
IW	18	148	*

Group II

Factor	n	Day	ADG (kg)
			NS
HF	7	177	1.57±0.05
SIM	10	177	1.62±0.04
Period			**
1		29	1.93 ± 0.08^{ACEa}
2		30	1.62 ± 0.08^{ADad}
3	17	22	0.94 ± 0.08^{Bbc}
4		17	2.29 ± 0.08^{Cc}
5		28	1.50 ± 0.08^{Ddf}
6		51	1.26 ± 0.08^{ABDef}
Breed x Period			**
HF1		29	1.96 ± 0.12^{ACac}
HF2		30	1.65 ± 0.12^{ACaa}
HF3		22	0.69 ± 0.12^{Bb}
HF4	7	17	2.09 ± 0.12^{Aa}
HF5		28	1.63 ± 0.12^{ACac}
HF6		51	1.39 ± 0.12^{Cc}
SIM1		29	1.91 ± 0.10^{Aa}
SIM2		30	1.59 ± 0.10^{ABab}
SIM3	10	22	1.20 ± 0.10^{Bb}
SIM4		17	2.50 ± 0.10^{Cc}
SIM5		28	1.37 ± 0.10^{ABb}
SIM6		51	1.14 ± 0.10^{Bb}
IW	17	177	NS

HF: Holstein–Friesian, BS: Brown–Swiss, SIM: Simmental, IW: Initial weight, ADG: Average daily gain, NS: Not significant, *P<0.05, **P<0.01, a,b,c,d,e,f: values in columns with different letters differ significantly (P≤0.05), A,B,C,D,E: values in columns with different letters differ significantly for (P≤0.01).

Table 6. Rib eye area (REA), subcutaneous fat thickness (SFT), pH0 and pH24 for HF, BS and SIM bulls

Breed	n	REA (cm^2)	SFT (cm)	pH0	pH24
Group I		**	NS	NS	NS
HF	10	66.82±2.83	0.23±0.03	6.54±0.06	5.92±0.02
BS	8	82.76±3.17	0.29±0.03	6.60±0.07	5.94±0.02
CCW		NS	NS	NS	NS
Group II		NS	NS	NS	NS
HF	7	69.50±4.10	0.49±0.08	6.51±0.07	5.74±0.04
SIM	10	76.50±3.43	0.36±0.07	6.50±0.06	5.77±0.04
CCW		NS	NS	NS	NS

HF: Holstein–Friesian, BS: Brown–Swiss, SIM: Simmental, NS: Not significant, ** P<0.01, pH: pH value for 0 and 24th hours, CCW: cold carcass weight.

kg) and BS (289.40±3.69 kg) in the first group were lower than the results reported by Başpınar *et al.* (1999), Koç and Akman (2003), Önenç (2003) and Aslan and Zülkadir (2009). HCW mean for SIM (309.25±3.45 kg) breed found in this study is lower than the results of Dannenberger *et al.* (2006) and Aslan and Zülkadir (2009), too. CCW means found in this study for HF in both groups and for SIM are also lower than the results of Önenç (2003) and Dannenberger *et al.* (2006), however, the means for HF and BS in the first group are higher than the results of Önenç (2003) and Sağöz *et al.* (2005).

While the FW of BS was lower than that of HF in the first group, the HCW, CCW and also DP (%) of BS was higher than those of HF. DP found in this study for HF in the first (52.51±0.59%) and second (53.47±0.72%) groups and for BS (54.40±0.66%) were higher than the results of two earlier reports (Alpan, 1972; Tüzemen *et al.*, 1990), but lower than the results of some previous reports (Akbulut and Tüzemen, 1994; Koç and Akman, 2003; Önenç, 2003; Sağöz *et al.*, 2005; Aslan and Zülkadir, 2009). The mean found in this study for SIM (54.29±0.60%) was also lower than the results reported by Dannenberger *et al.* (2006) and Aslan and Zülkadir (2009). DL (%) determined in this study for HF in the first (1.76±0.04%) and in the second (1.70±0.05%) groups and for BS (1.83±0.04%) were higher than Akbulut and Tüzemen (1994), but similar to the value of lighter group for HF reported by Koç and Akman (2003). DL found in this study for SIM (1.70±0.05%) was also lower than the value (1.89%) reported by Akbulut and Tüzemen (1994).

REA, SFT, pH0 and pH24, color coordinates (L*, a* and b*), CL and WBSF averages for the breeds are given in Table 6 and 7. Except for REA, (a*) and (b*) color coordinates in the first group and WBSF in the second group, all other differences between the breeds for both groups were determined to be statistically insignificant (P>0.05). In addition, except for WBSF in the second group, the effects of CCW on all traits were not significant (P>0.05) in both groups.

REA, SFT and pH24 means for HF and BS in the first group were 66.82±2.83 cm^2 and 82.76±3.17 cm^2 (P<0.01), 0.23±0.03 cm and 0.29±0.03 cm, 5.92±0.02 and 5.94±0.02, respectively. The means for the same traits for HF and SIM in the second group were 69.50±4.10 cm^2 and 76.50±3.43 cm^2, 0.49±0.08 cm and 0.36±0.07 cm, 5.74±0.04 and 5.77±0.04, respectively.

Similar to HCW, CCW and DP (%), the REA mean for BS was also higher than those of HF. REA determined in this study for HF in both groups were lower than the values of Koç and Akman (2003) and Önenç (2003), the mean found for HF in the first group (66.82±2.83 cm^2) is also lower but the mean in the second group for the same breed (69.50±4.10 cm^2) was similar to Alpan (1972). REA means found in this study for BS (82.76±3.17 cm^2) and for SIM (76.50±3.43 cm^2) breeds were higher than Alpan (1972) and Sağöz *et al.* (2005).

The ultimate pH determined in the cold carcass after cooling it about 24 hours decreased below 6.0 for all breeds. However, the ultimate pH24 of HF (5.92±0.02) and BS (5.94±0.02) in the first group were higher than those of the HF (5.74±0.04) and SIM (5.77±0.04) breeds in the second group. This difference between the groups could be due to lower muscle glycogen reserves in the first group due to lower FW and/or depletion of muscle glycogen due to being exposed to stress in the first group than those of the second group. As seen in Table 6, SFT means of HF and BS in the first group were also lower than those of HF and SIM in the second group. As a result of lower muscle glycogen or energy reserve of the animals in the first group, dark cutting beef was likely outcome from HF and BS in the first group compared to HF and SIM in the second group.

The pH24 found for HF in this study for both groups were higher than Kahraman *et al.* (2011). The pH24 of HF in the first group was similar to pasture gazed group but, lower than the concentrate fed group reported by Dannenberger *et al.* (2006). However, the pH24 of HF in the second group in this study was similar to concentrate fed group but, lower than the pasture gazed group of Dannenberger *et al.* (2006). For SIM, the pH found in this study was lower than Marencic *et al.* (2012) and concentrate fed group of Dannenberger *et al.* (2006), but similar to pasture gazed group of Dannenberger *et al.* (2006).

Similar to Sağöz *et al.* (2005), in this study it was also found insignificant differences between the breeds for SFT and the mean found for BS (0.29±0.03 cm) is about the same as the result reported for BS by Sağöz *et al.* (2005), but lower than the value for Charolais x BS crosses (0.39 cm) of Sağöz *et al.* (2005). The mean for HF (0.23±0.03 cm) in the first group in this study was also lower than Yüksel *et al.* (2009), but the value in the second group (0.49±0.08 cm) was higher than Yüksel *et al.* (2009).

Color coordinates means for HF and BS in the first group were detected to be 34.57±0.52 and 33.78±0.58 for (L*), 16.24±0.46 and 14.61±0.51 (P<0.05) for (a*) and 1.33±0.42

Table 7. Color coordinates (L*, a* and b*), cooking loss (CL, %) and WB shear force (WBSH, N) for HF, BS and SIM bulls

Breed	n	L*	a*	b*	CL	WBSF
Group I		NS	*	**	NS	NS
HF	10	34.57±0.52	16.24±0.46	1.33±0.42	25.10±1.77	40.21±7.64
BS	8	33.78±0.58	14.61±0.51	-0.68±0.47	25.87±1.98	53.54±8.55
CCW		NS	NS	NS	NS	NS
Group II		NS	NS	NS	NS	**
HF	7	35.25±0.70	16.54±0.43	0.63±0.31	26.63±1.10	40.89±4.56
SIM	10	34.77±0.59	15.87±0.36	0.31±0.25	27.09±0.92	60.67±3.81
CCW		NS	NS	NS	NS	*

HF: Holstein–Friesian, BS: Brown–Swiss, SIM: Simmental, CCW: Cold carcass weight, NS: Not significant, * P<0.05, ** P<0.01

and 0.68±0.47 (P<0.01) for (b*), respectively. The same coordinates for HF and SIM breeds in the second group were 35.25±0.70 and 34.77±0.59 for (L*), 16.54±0.43 and 15.87±0.35 for (a*) and 0.63±0.31 and 0.31±0.25 for (b*), respectively (Table 7).

CL for HF in the first and second groups were detected to be 25.10±1.77% and 26.63±1.10%, for BS and SIM breeds were 25.87±1.98% and 27.09±0.92%, respectively.

WBSF means found in this study for HF and BS in the first group were 40.21±7.64 N and 53.54±8.55 N (P>0.05), respectively. The means for HF and SIM in the second group were 40.89±4.56 N and 60.67±3.81 N (P<0.01), respectively. In this study, WBSF for HF in both groups had very close values to each other but these were smaller than those of BS and SIM.

In both groups, similar L* color coordinate means for HF with BS and SIM were obtained, but in the first group the beef from BS was more green and blue than those of the beef from HF (P<0.05). The L* values determined for HF in both groups are higher and also whiter than the earlier reports (Dannenberger *et al.*, 2006; Yüksel *et al.*, 2009; Kahraman *et al.*, 2011; Marencic *et al.*, 2012). For SIM breed, L* value found in this study is lower and also darker than Dannenberger *et al.* (2006) and Marencic *et al.* (2012). For HF, (a*) color coordinates found in both groups was similar to the values of Yüksel *et al.* (2009) and Kahraman *et al.* (2011), but the value found in this study for SIM was lower and greener than Marencic *et al.* (2012). For (b*) color coordinates found in both groups for HF and for SIM breeds were lower and bluer than the values of previous studies (Yüksel *et al.*, 2009; Kahraman *et al.*, 2011; Marencic *et al.*, 2012).

CL found in this study for HF in the first and second groups (25.10±1.77% and 26.63±1.10%, respectively), BS (25.87±1.98%) and SIM (27.09±0.92%) were lower than the values reported for HF for electrically stimulated and non–stimulated groups in the study of Kahraman *et al.* (2011) and for the value reported for Turkish Grey cattle by Soysal (2012).

Lower WBSF of HF beef found in this study than those of BS and SIM breeds shows that beef from BS and SIM breed is firmer than that of HF beef. Of all, the firmest beef was obtained from SIM breed. WBSF values determined in this study for HF (40.21±7.64 N and 40.89±4.56 N) and SIM (60.67±3.81 N) breeds were lower than Dannenberger *et al.* (2006), but higher than the value (48.95 N) reported for Turkish Grey cattle (Soysal, 2012). WBSF values found in this study for BS (53.54±8.55 N) and SIM breeds were also higher than the result reported for Turkish Grey Cattle (Soysal, 2012).

CONCLUSION

In this study, fattening performance, slaughtering, carcass and beef quality of HF bulls were compared to BS and SIM bulls. Due to high temperature and relative humidity seen in summer months in the region, some precautions such as changing the feeding regime and time and/or adapting a cooling system need to be implemented on this fattening farm and others in the region. Fattening performances of HF was similar to BS and SIM bulls, however, DP (%), and REA of BS bulls were higher than those of HF bulls, in addition to significant differences of (a*) and (b*) color coordinates between these two breeds. When fattening performances are concerned, paying more money to buy SIM or BS bulls instead of HF as fattening materials in the region would not provide any advantages to the producers, however, when carcass and beef quality traits are concerned BS bulls had some advantages on HF bulls. Between HF and SIM breeds, among all traits, only the significant difference is seen in WBSF.

Under the same environmental and nutritional conditions, IW is an important factor affecting the fattening performances of bulls and similar effect was also determined for slaughtering weight on carcass characteristics. In conclusion, although the IW and FW of HF were similar to those of BS and SIM breeds, in addition to different (a*) and (b*) color coordinates, DP (%) and REA means of BS were also higher than those of HF. Between HF and SIM breeds, only difference was determined for WBSF and the beef from SIM is firmer than that of beef from HF.

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