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Fattening performance, carcass traits, and profitability of Aberdeen Angus and Holstein Friesian bulls in Turkey

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Abstract

The aim of this study was to compare Aberdeen Angus (AA) and Holstein Friesian (HF) bulls in Turkey based on fattening performance, carcass properties, and production costs. In the trial, 105 AA and 105 HF 10- to 12-month-old bulls with a mean initial bodyweight (IBW) of 302 kg were used. The bulls were distributed into 14 paddocks in groups of 15 based on their IBW at an open-shed facility in İzmir. The bulls were fed different rations for the grower and finisher periods for 90 days each, but otherwise were kept under similar conditions. At the end of the finishing period, the animals were slaughtered and carcass characteristics, organ weights, quality of meat, and meat production costs were evaluated. In terms of fattening performance, the AA bulls were superior to the HF bulls. The ultimate pH of the *Longissimus dorsi* in the AA bulls was lower than in the HF bulls and the sensory characteristics of the AA bulls were higher. Production costs were higher for the AA bulls, but so too were income over feed costs (IOFC), making the AA bulls more profitable. Thus, it might be concluded that beef breed bulls that mature quickly, such as AA, are more advantageous for meat production in Turkey than HF bulls, which are a by-product of the dairy industry.

Keywords: beef, bulls, dairy, economics, fattening performance, meat quality
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Introduction

There are numerous differences between countries in the breeds of beef cattle and in the production system, sex condition, type of feeding, age at the onset of fattening, slaughter age, and initial and final bodyweights (Bureš & Bartoň, 2018; Panea *et al.*, 2018). Despite increased numbers of beef cattle, dairy and crossbred cattle still constitute most of the germplasm used for beef production in Turkey. The HF has become the most prevalent breed countrywide, with 5.5 million purebreds and 856 000 crossbred animals (Ardıçlı *et al.*, 2018; Kul *et al.*, 2020). Although HF cattle are known worldwide for dairy production, they are important in beef production (Bartoň *et al.*, 2003). Previous studies reported differences among breeds in fattening performance and meat quality (Cundiff *et al*., 2001; Holló *et al.*, 2012; Jiu *et al.*, 2019). However, these differences have not been entirely consistent (MacNeil *et al.*, 1989).

The demand for beef in Turkey cannot be entirely satisfied with male and surplus female calves as a by-product of dairy production, and this demand is expected to increase with population and income level. Up to 90% of future meat consumption in Turkey is expected to involve beef (TUIK, 2019). It is thought that this problem cannot be overcome with meat produced only from dairy breeds and dairy-beef crossbreds. Thus, there is a role for purebred beef cattle to increase the quantity and quality of domestic beef production in Turkey.

In a study comparing the fattening performance and carcass characteristics of bulls from Simmental, Aberdeen Angus (AA), Hereford, Limousin, and Charolais breeds in the conditions found in Turkey, Duru and Sak (2017) reported live weight, daily weight gain, and carcass weight of AA cattle of 543.3, 1.3, and 317.7 kg, respectively, values that were lower than those for Charolais, but were competitive with the other breeds. However, Duru and Sak (2017) concluded that 'as the pastures in Turkey are not sufficient in terms of area and productivity, breeding purebred beef cattle whose production system is based on broad and productive

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pastures does not seem economical'. Therefore, it is the commonplace recommendation that beef production in Turkey should be carried out with breeds that are used in milk production, with crosses with these breeds, and with indigenous breeds (Alpan, 1972; Arpacik *et al.*, 1988; Yanar *et al.*, 1990).

Because of these differences in opinion, few studies have compared the performance, meat quality, and carcass yield of beef and dairy breeds under Turkish conditions. Because breeds are continually evolving, Clarke *et al.* (2009) indicated the need for such studies to reassess the differences between breeds in production properties. Further, many of the comparisons among breeds for fattening performance, carcass merit and palatability were conducted with steers rather than intact bulls. Because of this, the present study was conducted to compare the fattening performance, carcass characteristics, physicochemical and sensory properties of the meat and production costs of HF and AA bulls under Turkish conditions.

Materials and Methods

The use of animals in this experiment was approved by Ege University Animal Care and Use Committee (No: 2017-035).

In this study, 210 10- to 12-month-old bulls were subjected to the same care and feeding conditions. A total of 105 AA bulls were imported from Uruguay and 105 HF were obtained from various markets in Turkey. The trial was carried out between September 2017 and March 2018 at open-shed fattening facilities of the firm Dikili Çiftlik A.Ş. This beef cattle farm is located in Dikili in Izmir Province in the West Anatolian Region of Turkey (at 39°4′21.9972″ N and 26°53′23.0028″ E) with an average altitude of 2 m above sea level. The average annual temperature at the location is 16.5 °C and ranges from 8 °C during winter to 25.5 °C during summer. The average annual rainfall is 652 mm.

At the beginning of the trial, the animals were stratified by bodyweight (BW) and randomly assigned to 14 paddocks, seven for each breed. Prior to the experiment, all animals were injected with the vitamin supplementation Ademin (Ceva Animal Health, Inc., Istanbul, Turkey) 1 ml/50 kg BW, and were treated for internal and external parasites with Dectomax (Zoetis Inc., Parsippany-Troy Hills, New Jersey, USA) at 1 ml/50 kg BW. The bulls were adapted to the diets for 14 days before a growth performance trial. Initially the bulls were fed a diet composed of 50% alfalfa hay and 50% the grower diet. Over the 14-day adaption period the alfalfa hay was replaced gradually with the grower diet. After the adaptation period, the bulls were fasted for 16 hours and then weighed. The mean weight at this time was 298.96 ± 1.54 kg, which was used as the initial BW for the study.

The animals were fed a grower ration for the first 90 days, followed by a finisher ration for an additional 90 days (Table 1). The rations were based on the National Research Council (NRC) Nutrition Requirement of Beef Cattle (NRC, 2000). The chemical analyses were carried out at Ege University, Faculty of Agriculture, Department of Animal Science and Animal Feed Chemical Analysis Laboratory. Atomic absorption spectroscopy (Ultrospec 2100 Pro, Biochrom US, Holliston, Massachusetts, USA) was used to determine calcium (Ca) concentrations. The phosphorus (P) content of the materials was determined using a spectrophotometer (Double Beam UV-V15, Perkin Elmer, Istanbul, Turkey) with calorimetric methods. Metabolizable energy (ME) (kcal/kg DM) was estimated based on the nutrient content (protein (CP), fibre (CF), and fat (EE) levels) using the prediction equation:

$$ME = 3260 + (0.455xCP + 3.517xEE - 4.037xCF) \qquad (TSI, 1991)$$

At the beginning and end of the trial the BW of each animal was measured twice. At 14-day intervals during the trial the bulls were taken off feed for 16 hours, after which time a shrunk BW was recorded. Total weight gain (TWG) was calculated as the difference between initial BW and slaughter BW. Average daily gain (ADG) was TWG/180. Feed was provided twice daily, in the morning and evening. The feed and fresh water were available ad libitum. The quantities of feed offered and refused in each paddock were weighed and recorded daily to determine dry matter intake (DMI). Dry matter intake was calculated at group level by using the difference between the feed put into the paddocks and the remaining feed throughout the trial. The feed conversion ratio (FCR) was determined at group level by dividing ADG by DMI.

At the end of the experiment, all bulls were fasted for 16 hours, weighed, and then transported to a commercial abattoir 120 km from the farm, where they were slaughtered the same day. Hot carcass weight (HCW) was recorded immediately after dressing. Dressing percentage (DP) was calculated as the ratio of HCW to slaughter BW. The liver, heart, spleen, kidneys, internal fats (pelvic fat, kidney fat, omental fat, and total fat), and hide that were separated from the carcasses during slaughter were weighed.

Table 1 Compositions of the grower and finisher total mixed ration (g/kg), nutritional substance contents (%), and metabolic energy (kcal/kg) levels (as feed)

Ingredient, g/kg	Grower	Finisher	Nutrient, %	Method of Analysis	Grower	Finisher
Wheat straw	243.6	143.2	Dry matter	AOAC 934.01	71.7	78.8
Corn silage	127.1	62.3	Crude protein	AOAC 990.03	15.6	13.4
Cotton seed	66.7	31.1	Ether extract	AOAC 920.39	3.4	3.0
Barley	110.2	359.9	Crude fibre	AOAC 962.09	23.2	15.6
Corn grain	91.1	179.5	NDF	Van Soest *et al.* (1991)	44.5	35.3
Cotton meal	76.3	46.7	ADF	Van Soest *et al.* (1991)	19.7	17.8
Sunflower meal	132.4	65.4	Crude ash	942.05	5.6	4.9
Wheat bran	46.6	63.3	Calcium		0.9	0.6
Soybean hull	77.3	28.0	Phosphorus		0.4	0.5
Ground limestone	21.2	13.4	Starch	AOAC 14031.32	18.8	38.2
Salt	3.4	3.2	Sugar	EC (2009)	2.4	2.5
			ME kcal/kg		2530	2854

NDF: neutral detergent fibre, ADF: acid detergent fibre, ME: metabolizable energy

After slaughter, the carcasses were kept in cold storage at 2 °C for 24 hours. Back fat thickness was measured near the LD on the left half of the carcasses between the 12th and 13th ribs using digital callipers. Sixty bulls from each breed were randomly selected and an approximately 2.5 cm thick steak was cut from the LD at the 12th rib. These steaks were kept initially at 4 °C and then frozen and stored at -20 °C until being analysed for meat quality.

The pH of the LD was measured with a pH meter (Hanna, HI 8314, Hanna Instruments, Smithfield, Rhode Island, USA). The CIE Lab values (L^*: relative lightness, 0 = black to 100 = white; a^*: redness, -50 = green to +50 = red; and b^*: yellowness, -50 = blue to +50 = yellow) were measured on the surface of *Longissimus thoracis et lumborum* using a Color Flex spectrophotometer (Hunter Lab, Reston, Virginia, USA). Before each measurement, the apparatus was standardized against a white plate (CIE, 1986). Three readings were obtained from each sample.

A trained taste panel was organized for sensory analyses. After removal from the freezer, the steaks were thawed at 4 °C for 24 hours and cooked on a grill for 5 minutes. Each panellist scored the cooked samples using an 8-point hedonic scale. The panellists assigned a score for appearance, juiciness, flavour, and overall acceptability (Keeton, 1983). For appearance: 8 = extremely good, 7 = very good, 6 = moderately good, 5 = slightly good, 4 = neither good nor bad, 3 = moderately bad, 2 = very bad, and 1 = extremely bad. For juiciness: 8 = extremely juicy, 7 = very juicy, 6 = moderately juicy, 5 = slightly juicy, 4 = slightly dry, 3 = moderately dry, 2 = very dry, and 1 = extremely dry. For intensity of flavour: 8= extremely intense, 7 = very intense, 6 = moderately intense, 5 = slightly intense, 4 = slightly bland, 3 = moderately bland, 2 = very bland, and 1 = extremely bland. For overall acceptability: 8 = extremely acceptable; 7 = very acceptable; 6 = moderately acceptable, 5 = acceptable, 4 = slightly unacceptable, 3 = moderately unacceptable, 2 = very unacceptable, and 1 = extremely unacceptable. Oxidized flavour was scored on a 3-point scale (Carr *et al.*, 1999) with 1 = least liked and 3 = most liked.

The economic analysis considered both cost and revenue. The initial purchase cost of each animal was recorded. Feed cost, calculated per paddock, was the product of weight of feed consumed and the current unit price of the feed. Additionally, costs for medication, labour, and veterinary treatment were recorded regularly. The 'per animal profitability as gross margin' was calculated based on the difference between the revenue obtained from carcass sales and the sum of the costs. In addition, income over feed cost (IOFC) was calculated for each animal as the difference between carcass revenue and feed cost (Tayengwa *et al.*, 2020).

Statistical analyses were performed using the linear model procedures in SAS version 9.1 (SAS Institute Inc., Cary, North Carolina, USA) with the individual animal as an experimental unit. Initial bodyweight was regarded as a potential covariate. However, it was not used as a covariate because it did not explain a significant amount of variation. Thus, the model was a one-way classification that contained only breed effects. Means were generated with the LSMEANS statement and separated using the DIFF function when the F-statistic was significant (P <0.05).

Results and Discussion

The fattening performance of the AA and HF bulls is summarized in Table 2. Compared with the HF bulls, the AA bulls grew faster, were heavier at the end of the experiment, consumed more feed, and were more efficient in converting feed to BW gain (*P* <0.01). The better performance of AA bulls compared with HF bulls was similar to the study by Holló *et al.* (2012), who reported significant differences in terms of fattening performance between the HF and early maturing beef cattle breeds such as the AA. In contrast, Bureš and Bartoň (2018) found no difference in DWG, DMI or FCR between AA and HF cattle with similar initial ages after a 280-day feeding. In addition, Bown *et al.* (2016) reported that differences in growth rate in the HF and the early developing beef cattle breeds such as AA were generally negligible.

Table 2 Fattening performance of Aberdeen Angus and Holstein Friesian bulls

	Initial BW, kg	Slaughter BW, kg	Total weight gain, kg	Daily gain, kg/day	Dry matter intake, kg/day	Feed conversion
Angus	298.14 ± 1.56	587.30 ± 2.14	289.16 ± 1.31	1.59 ± 0.01	11.96 ± 0.07	7.47 ± 0.04
Holstein	302.67 ± 4.76	523.76 ± 5.33	221.09 ± 5.46	1.21 ± 0.02	10.42 ± 0.10	8.47 ± 0.08
Mean	298.9 6± 1.54	575.78 ± 2.36	276.82 ± 1.98	1.52 ± 0.01	11.68 ± 0.07	7.66 ± 0.04
P-value	0.258	0.001	0.001	0.001	0.001	0.001

BW: bodyweight

The HCW and DP were significantly higher in the AA bulls compared with the HF (Table 3). This difference might be explained by the higher slaughter BW in the AA. These results were compatible with those reported by Bureš and Bartoň (2018) and Holló *et al.* (2012). In the present study, the DP value obtained for the HF cattle was lower than that obtained by Bartoň et al. (2003), Holló *et al.* (2012), and Kızıl & Aydoğan (2014), whereas it was consistent with the values reported by Catıkkas and Atakan (2017), Holló *et al.* (2012) and Duru and Sak (2017). The inconsistency of the results between studies was probably owing to differences in initial BW, the length of time on feed, and the diet.

Table 3 Carcass traits of Aberdeen Angus and Holstein Friesian bulls slaughtered after 180 days on feed

Carcass trait	Angus	Holstein	Mean	*P*-value
Hot carcass weight, kg	329.63 ± 1.26	271.09 ± 2.89	319.02 ± 1.63	0.001
Dressing percentage, %	56.12 ± 0.05	51.95 ± 0.57	55.36 ± 0.14	0.001
Pelvic fat, kg	6.59 ± 0.04	6.55 ± 0.04	6.57 ± 0.03	0.612
Kidney fat, kg	6.71 ± 0.03	6.68 ± 0.06	6.70 ± 0.03	0.765
Omental fat, kg	6.27 ± 0.06	7.37 ± 0.07	6.82 ± 0.06	0.001
Heart fat, kg	1.09 ± 0.02	1.79 ± 0.03	1.44 ± 0.03	0.001
Total fat, kg	20.67 ± 0.12	22.41 ± 0.19	21.54 ± 0.14	0.001
Fat thickness, mm	8.17 ± 0.13	3.38 ± 0.11	5.75 ± 0.23	0.001

The weights of the omental and heart fat depots in the HF bulls were significantly greater than in the AA, whereas pelvic fat and kidney fat were similar in the two breeds (*P* >0.05) (Table 3). However, the AA bulls had more subcutaneous fat than the HF (*P* >0.05). Holló *et al.* (2012) reported a kidney fat weight of 9.06 kg for AA cattle, which was greater than was observed in the present study. However, they found a total fat weight of 21.08 kg in AA, which was similar to that observed in the present study. For HF, Holló *et al.* (2012) found 4.47 kg of kidney fat and 8.22 kg of total fat, values which are lower than those found in the present study. Kızıl and Aydoğan (2014) and Diler *et al.* (2016) reported greater values of fat thickness for HF than were observed in this study. Jiu *et al.* (2019) observed 42% greater fat thickness in AA (11.61 mm) than was observed in the present study. Nour *et al.* (1983), in parallel with the present results, observed that the kidney, pelvic, and heart fat amounts were similar in the HF and AA at carcass weights between 250 and 350 kg. However, they observed that fat accumulation was greater in the HF compared with AA at heavier weights.

The weights of heart, kidney, liver, and spleen in the AA bulls were lower than those in the HF bulls (*P* <0.05) (Table 4). The higher heart and liver weights observed in the HF compared with the AA might be associated with their being dairy breeds. The liver, heart, kidney, and spleen weights of HF reported by Diler *et al.* (2016) were similar to the results of the present study. Kızıl and Aydoğan (2014) found the heart, spleen, and kidney weights were similar, liver weight lower, and kidney fat weight higher than those in the present study. The hide weight of AA cattle observed here was higher than that reported by Duru and Sak (2017).

Table 4 Organ weights of Aberdeen Angus and Holstein Friesian bulls

	Heart, kg	Kidney, kg	Liver, kg	Spleen, kg	Hide, kg
Angus	1.16 ± 0.02	0.67 ± 0.01	5.86 ± 0.06	1.09 ± 0.02	42.54 ± 0.52
Holstein	1.81 ± 0.04	1.08 ± 0.04	7.02 ± 0.07	1.24 ± 0.02	41.20 ± 0.42
Mean	1.49 ± 0.03	0.88 ± 0.02	6.44 ± 0.07	1.17 ± 0.02	41.87 ± 0.34
P-value	0.001	0.001	0.001	0.001	0.048

The growth potential and DP in particular and the composition of dairy breeds were generally inferior to beef breeds (Coyne *et al*., 2019). This decrease in DP might be attributed to increased weight of the drop, the increased amount of intra-abdominal fat and increased weight of the liver, decreased muscle score, and reduced subcutaneous fat depth (Schaefer, 2005). Ferrell (1988) also reported that the liver and digestive system tissues utilize significant amounts of energy. The larger sizes of these organs in the HF are an indicator that this breed may allocate more of the consumed energy to these tissues than AA. Because these tissues contribute to the mass of the drop, a lower DP would be expected in HF compared with AA.

Consumers' perceptions of meat quality are based on its appearance (Warner *et al*., 2010). The colour (*L**, *a**, *b**) of the LD was similar between the breeds (*P* >0.05) (Table 5). Bureš and Bartoň (2018) also observed no significant difference between AA and HF in colour of the *Longissimus lumborum* between the 9th and 11th ribs. Nor did Çatıkkaş and Koç (2017) find colour of the LD to differ between breeds. The colour of the meat is an important quality characteristic that determines purchasing decisions by the consumer (Muchenje *et al.*, 2009). The main pigment in meat is myoglobin. When myoglobin is exposed to air, it is oxidized to form oxy-myoglobin, which is a bright red pigment that is attractive for consumers and associated with freshness. At lower partial oxygen pressures, myoglobin is oxidized into metmyoglobin, which is brown and not attractive (Renerre, 1990). Additionally, the formation of metmyoglobin is affected by pH and the oxygen amount in the post-mortem muscles, which are chemical reduction conditions for muscles (Renerre & Labas, 1987). For this reason, the colour of meat is determined by the existing pigmentation level and the proportional percentages of myoglobin, oxymyoglobin, and metmyoglobin (Muir *et al.*, 1998).

The pH of the meat from AA was significantly lower than that from HF (Table 5). Wulf and Wise (1999) reported that muscle colour is correlated with the pH of the muscle. The pH value of meat right after slaughter is in the range of 7.0 - 7.2. After slaughter, conversion of glycogen in the meat to lactic acid causes the pH to decrease to 5.0 - 5.4 at rigor mortis and muscles start to soften (Fuente *et al.*, 2006). It is also thought that the pH value is associated with the meat's firmness, colour, and water retention capacity, and therefore its taste (Swatland, 2004). Thus, the lower pH in the AA cattle in the present study might be partially responsible for the observed differences in overall acceptability, flavour and appearance when compared with meat from HF.

While the variations in growth, feed intake and carcass structure have ramifications for cattle producers and the meat industry (Pesonen & Huuskonen 2015), consumers are more concerned with the nutritional value of the meat and its sensory characteristics (Bureš & Bartoň, 2018). There were no significant differences between the AA and the HF in juiciness and oxidized flavour (*P* >0.05), whereas the appearance and flavour values were greater in the AA compared with the HF (*P* <0.05). In terms of overall acceptability, the value for the AA was greater than that for the HF (*P* <0.05). Based on this, it was seen that the AA was superior to the HF in physical and sensory characteristics (Table 5).

Table 5 Meat colour, pH, and sensory analysis of the *Longissimus dors*i from Aberdeen Angus and Holstein Friesian bulls fed for 180 days

	Angus	Holstein	Mean	*P*-value
Meat colour				
Lightness (L*)	36.04 ± 0.4	36.75 ± 0.5	36.39 ± 0.3	0.344
Redness (*a**)	18.65 ± 0.2	17.65 ± 0.5	18.14 ± 0.3	0.087
Yellowness (b*)	9.46 ± 0.3	9.55 ± 0.4	9.50 ± 0.3	0.874
pH	5.48 ± 0.1	5.61 ± 0.1	5.54 ± 0.1	0.001
Sensory properties				
Appearance	6.20 ± 0.1	5.30 ± 0.1	5.75 ± 0.1	0001
Juiciness	5.15 ± 0.2	4.65 ± 0.2	4.90 ± 0.2	0.146
Flavor	5.65 ± 0.1	4.60 ± 0.2	5.12 ± 0.2	0.001
Oxidized flavor	1.50 ± 0.1	1.60 ± 0.1	1.55 ± 0.1	0.574
Acceptability	5.80 ± 0.2	5.10 ± 0.2	5.45 ± 0.2	0.040

Although the taste of the meat between early and late-developing beef bulls and dairy bulls is affected by many factors, the quantity of intramuscular fat is notable (Bureš & Bartoň, 2018). Higher intramuscular fat amounts are related to earlier maturation (Bonny *et al.*, 2016). Lizaso *et al.* (2011) argued that the breed effects on sensory attributes may be usually explained by differences in the muscle lipid content. Holló *et al.* (2012) determined the intramuscular fat contents of the *M. Longissimust horacis*, *M. semitendinosus*, and *M. psoas* major muscles were 4.42, 2.11, and 4.74 for AA cattle and 2.27, 1.15, and 2.91 for HF cattle, respectively. Bureš and Bartoň (2018) reported scores for tenderness, juiciness, flavour, and fibrosity of meat as 6.7, 6.4, 6.6, and 6.1 in the AA and 4.1, 5.4, 5.7, and 5.1 in the HF, respectively.

The importance of meat tenderness in consumer acceptability of meat has long been recognized (Mennecke *et al.*, 2007). Tenderness or softness of meat has two main components. The first is the myofibrillar (muscle) component, whereas the other is the connective tissue (collagen) component. The myofibrillar component of softness may be affected by the activity of proteolytic enzymes (especially calpains) during the 'ageing' of the post-mortem carcass muscles, and this is an important determinant of meat firmness (Koohmaraie, 1992). Cattle that reach slaughter maturity early produce softer meat than slow-growing counterparts (Aberle *et al.*, 1981; Fishell *et al.*, 1985). The connective tissue component affecting meat firmness covers the intramuscular collagen content and solubility. Shimokomaki *et al.* (1972) reported that changes in collagen stabilization and cross-linking are more closely related to growth rate and animal maturity. Hall and Hunt (1982) stated that collagen solubility is highest at the stage of fast growth, and cattle that reach maturity fastest are more likely to contain more soluble collagen and softer meat. As supporting evidence, Bureš and Bartoň (2018) found the soluble collagen ratio higher in AA than in HF. These results of previous studies may be an explanation for the higher overall acceptability of meats from the AA cattle than meat from the HF cattle in the present study.

The initial animal costs and the feed costs in the total fattening period were higher for the AA bulls than for the HF bulls (Table 6). However, the revenue from the sale of the carcasses of the AA cattle and the net profit derived from them was higher (Table 6). These differences between the breeds were statistically significant. Likewise, the gross margin and IOFC value for the HF bulls were lower than those for the AA bulls ($P < 0.05$).

In addition to breed, sex, nutrition, and genetics, the optimum slaughter age for obtaining the maximum net profit may vary based on economic factors such as feed costs and carcass prices (Marti *et al.*, 2013; Üstüner *et al.*, 2017). Schenkel *et al.* (2004) reported that FCR and fast growth have a large effect on beef production costs. As supporting evidence, the FCR and DWG values in the AA bulls in the present study were better than those of the HF bulls. On the other hand, Rust and Abney (2005) reported that there is little difference in the FCR of the HF breed and beef breed such as the AA grown at low weights (140 kg), but as the body weights increase (up to 400 kg), beef breeds become increasingly more productive than HF cattle. Also, IOFC is a critical metric of on-farm profitability (Elliott, 2016). Indeed, the IOFC value was found to be greater for AA than for HF. In the present study, the increased IOFC results from higher growth rate led to greater final weight, greater carcass value and better utilization of the feed by AA bulls than by HF bulls.

Table 6 Economic comparison of producing beef from Aberdeen Angus and Holstein Friesian bulls

	Angus, US$	Holstein, US$	Mean, US$	*P*-value
Animal cost	921.80 ± 4.8	890.43 ± 14.1	916.11 ± 4.7	0.010
Feed cost	442.46 ± 2.8	423.39 ± 4.9	439.01 ± 2.5	0.003
Pharmaceutical cost	3.98 ± 0.1	5.54 ± 0.9	4.26 ± 0.2	0.003
Labour cost	30.17 ± 0.1	32.35 ± 0.1	30.56 ± 0.1	0.001
Carcass revenue	1677.78 ± 6.1	1515.42 ± 16.2	1648.33 ± 6.6	0.001
Gross margin	279.35 ± 4.3	164.07 ± 18.7	258.45 ± 5.3	0.001
Income over feed cost	1235.31 ± 5.4	1092.10 ± 16.1	1209.65 ± 6.0	0.001

Conclusion

The lower feed costs, higher DP, and more suitable carcass quality and characteristics observed for the AA bulls resulted in significantly higher beef production in comparison with the HF bulls. Based on previous evidence and the present study, it could be concluded that meat from AA bulls has better organoleptic properties than meat from HF bulls and thus provides a better product for consumers. Therefore, according to the findings of the present study, the preference for fast-growing beef cattle breeds such as the AA in meat production in Turkey has significant advantages in the economic sense and in terms of meat quality.

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Authors' Contributions

HBÜ designed the study. HBÜ and HHİ executed the study. HBÜ and HHI implemented the study and analyzed the samples. HBÜ and HHİ drafted the manuscript.

Conflict of Interest Declaration

There is no conflict of interest.

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