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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Fattening Performance and Carcass Characteristics of Akkaraman and Asaf x Akkaraman F_1 Crossbred Lambs*

Akkaraman ve Asaf x Akkaraman Melezi F_1 Kuzularının Besi Performansı ve Karkas Özellikleri

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Abstract

The objective of study was to determine the fattening performance and carcass characteristics of Akkaraman and Assaf x Akkaraman (ASF x AK) F_1 crossbred male lambs obtained by crossing Assaf rams with Akkaraman ewes under breeding conditions. While the initial live weights of Akkaraman and (ASF x AK) F_1 crossbred lambs were 23.89 kg and 23.77 kg, their final live weights were 41.02 kg and 44.03 kg ($p<0.01$), respectively. In 70 days of intensive fattening, purebred and crossbred lambs gained 17.14 kg and 20.26 kg total live weight, respectively. The feed intake of both groups for 1 kg live weight gain was 4.70 kg and 4.15 kg, respectively. Crossbred F_1 lambs had significantly greater withers height ($p<0.01$) and body length ($p<0.01$) than Akkaraman lambs at all stages of fattening. At finishing, (ASF x AK) F_1 lambs had the highest body length, larger chest, and leg circumferences than Akkaraman lambs. Among the slaughter and carcass characteristics of Akkaraman and (ASF x AK) F_1 lambs, slaughter weight, cold carcass weight, untailed cold carcass weight, left half carcass weight, dressing percentage and the area of *Musculus longissimus dorsi* were determined to be 39.22 kg and 44.34 kg ($p<0.05$), 19.60 kg and 21.40 kg ($p<0.05$), 15.86 kg and 19.22 kg ($p<0.01$), 7.20 kg and 9.41 kg ($p<0.001$), 50.04% and 48.28%, 12.49 cm^2 and 14.24 cm^2, respectively. Crossbred F_1 lambs had statistically significantly higher values for head, foot, skin, testes and kidney+pelvic fat weights than pure lambs. The tail weights of purebred and crossbred F_1 lambs were determined to be 3.74 and 2.18 kg, respectively ($p<0.001$). The crossbred F_1 lambs were found to have a higher leg weight (3.48 kg vs. 2.92 kg, $p<0.01$), forearm weight (1.80 kg vs. 1.44 kg, $p<0.01$), and flank-chest weight (1.39 kg vs. 0.92 kg, $p<0.01$) compared to Akkaraman lambs. As a result, (ASF x AK) F_1 crossbred lambs were found to have better fattening performance, slaughter and carcass characteristics than Akkaraman lambs.

Keywords: Crossbreeding, Intensive fattening, Lamb, Slaughter, Body measurement, Carcass

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Öz

Çalışmanın amacı, Asaf koçları ile Akkaraman koyunlarının yetiştirici koşullarında melezlenmesi ile elde edilen Akkaraman ve Asaf x Akkaraman (ASF x AK) F_1 melezi erkek kuzuların besi performansı ve karkas özelliklerini belirlemektir. Akkaraman ve (ASF x AK) F_1 melez kuzuların besi başı canlı ağırlıkları sırasıyla 23.89 kg ve 23.77 kg, besi sonu canlı ağırlıkları ise sırasıyla 41.02 kg ve 44.03 kg olarak bulunmuştur ($p<0.01$). Yetmiş günlük entansif besi sonunda saf ve melez kuzular sırasıyla 17.14 kg ve 20.26 kg toplam canlı ağırlık kazanmışlardır. Her iki grubun 1 kg canlı ağırlık artışı için yem tüketimi sırasıyla 4.70 kg ve 4.15 kg olarak belirlenmiştir. Melez F_1 kuzuların, besi döneminin tüm aşamalarında cidago yüksekliği ($p<0.01$) ve vücut uzunluğu ($p<0.01$), Akkaraman kuzularına kıyasla önemli derecede daha yüksek bulunmuştur. Besi sonunda (ASF x AK) F_1 kuzuları, Akkaraman kuzulara göre daha yüksek vücut uzunluğuna, daha büyük göğüs ve but çevrelerine sahip olmuştur. Akkaraman ve (ASF x AK) F_1 kuzuların kesim ve karkas özelliklerinden kesimhane ağırlığı, soğuk karkas ağırlığı, kuyruksuz soğuk karkas ağırlığı, sol yarım karkas ağırlığı, karkas randımanı ve *Musculus longissimus dorsi* alanı sırasıyla 39.22 kg ve 44.34 kg ($p<0.05$), 19.60 kg ve 21.40 kg ($p<0.05$), 15.86 kg ve 19.22 kg ($p<0.01$), 7.20 kg ve 9.41 kg ($p<0.001$), %50.04 ve %48.28, 12.49 cm^2 ve 14.24 cm^2 olarak belirlenmiştir. Melez F_1 kuzular, baş, ayak, post, testis ve böbrek+leğen yağ ağırlıkları bakımından Akkaraman kuzulardan istatistiksel olarak önemli derecede daha yüksek değerlere sahip olmuştur. Saf ve melez F_1 kuzuların kuyruk ağırlığı sırasıyla 3.74 ve 2.18 kg olarak belirlenmiştir ($p<0.001$). Melez F_1 kuzular, Akkaraman kuzulara kıyasla daha yüksek but ağırlığına (3.48 kg ve 2.92 kg, $p<0.01$), ön kol ağırlığına (1.80 kg ve 1.44 kg, $p<0.01$) ve etek ağırlığına (1.39 kg ve 0.92 kg, $p<0.01$) sahip olmuştur. Sonuç olarak, (ASF x AK) F_1 melezi kuzuların Akkaraman kuzulara göre daha iyi besi performansı, kesim ve karkas özelliklerine sahip olduğu tespit edilmiştir.

Anahtar Kelimeler: Melezleme, Entansif besi, Kuzu, Kesim

1. Introduction

Sheep breeding plays an essential role in Türkiye's livestock sector. The number of sheep is 44 million heads (TUIK, 2024). It is estimated that approximately 94% of Türkiye's sheep population consists of indigenous breeds, while 6% are exotic breeds and crossbreeds. The indigenous sheep breeds demonstrate a heterogeneity of characteristics regarding productivity and physical characteristics in response to adaptation to different environments, vegetation, climate, and geographical regions (Selvi and Üstüner, 2021).

It is estimated that approximately 25% of the global sheep population is characterized by the presence of fat tails. Certain breeds of fat-tailed sheep can accumulate up to 20% of their total carcass weight in the form of tail fat (Mohapatra and Shinde, 2018). The sheep population in Türkiye predominantly consists of fat-tailed, multi-purpose, and low-yielding local breeds. Sheep are generally reared on family farms under extensive conditions based on pasture and traditional methods. Sheep play a pivotal role as a source of red meat in Türkiye, with an average consumption of 4.2 kg per person (Aydin et al., 2024). German Meat Merino, Border Leicester, Dorset Down, Ile de France, Hampshire Down, Lincoln, and German Black Headed meat sheep breeds were imported to increase the quantity and quality of meat from local sheep breeds (Ceyhan et al., 2008; Üçtepe, 2016). Akkaraman sheep breed, which constitutes 40.88% of the country's sheep population (Kandemir et al., 2024), has been shown to demonstrate a degree of resistance to diseases and harsh conditions. They are easy to handle and have good mothering ability (Anonymous, 2009). Consequently, it has been utilized as a dam material in the majority of breeding studies. The Assaf sheep breed, utilized as the sire line in this study, is a semi-fat-tailed breed that has been obtained through crossbreeding the improved Awassi sheep with the East Frisian breed. The lamb yield is high, so it is grown for lamb and milk production (Pollott and Gootwine, 2004). No research has yet been conducted into the potential to enhance the meat yield characteristics of Akkaraman ewes through crossbreeding with the Assaf breed. Therefore, this study tested the hypothesis that the Assaf breed could be used to increase the meat production capacity of Akkaraman sheep. The purpose of the study was to examine the fattening performance, body measurements, and carcass characteristics of Akkaraman and (ASF x AK) F_1 crossbred lambs.

2. Materials and Methods

2.1. Animal material

The experiment was conducted at the rural farm conditions. A crossbreeding program was carried out between Akkaraman ewes and Assaf rams to obtain the study material lambs. A natural mating program was applied to Akkaraman rams and ewes at pasture. Due to the difficulty of mating semi-fat-tailed Assaf rams with fat-tailed Akkaraman ewes, hand mating was performed between Akkaraman ewes and Assaf rams. Ewes determined to be in heat by the teaser rams were separated and placed in a small mating pen with Assaf ram for hand mating. The tail region of Akkaraman ewe was lifted to allow the Assaf ram to mate easily. To determine fattening performance, 10 Akkaraman and 9 (ASF x AK) F_1 crossbred lambs were randomly selected from single-born male lambs weaned at 90 days of age.

2.2. Fattening performance

All lambs were treated for internal and external parasites before fattening. After all lambs were accustomed to the fattening feed for one week, the 70-day fattening period was started. Lambs were given 100 g/day/head of chopped dry alfalfa hay and concentrated feed ad-libitum during the fattening period. The nutritional composition of the concentrate feed and alfalfa hay used in the fattening period is given in *Table 1*. All lambs had free access to drinkable water and mineral stones. In the study where group feeding was applied, the feeds given and left to the lambs during the fattening period were weighed every 14 days. Daily concentrate feed consumption was determined by calculating the difference between consumed feed and leftover feed. Feed conversion ratio was calculated by dividing total weight gain by total feed consumption. Live weights of lambs, fasted for approximately 12 hours, were recorded biweekly before morning feeding. At the same time, various body measurements were taken of the lambs. With the help of a measuring stick, the withers height, body length, chest width, and chest depth measurements were determined, while the chest girth and leg circumference were measured with a measuring tape (Al-Barwari, 2024).

Table 1. Nutritional composition of the concentrate feed and alfalfa hay used in fattening period

Nutrient (%)	Concentrate Feed	Alfalfa Hay
Dry matter	90.04	92.40
Crude protein	17.00	14.73
Crude fiber	6.00	30.05
Crude ash	7.50	4.15
Crude fat	4.00	0.95
ADF (Acid Detergent Fiber)	16.75	50.70
NDF (Neutral Detergent Fiber)	34.10	51.70

2.3. Slaughtering and carcass characteristics

At the end of the fattening period, 5 randomly selected lambs from each genotype were slaughtered to determine the slaughter and carcass characteristics. The lambs were fasted for 18 hours, with free access to water, and weighed immediately before slaughter. All slaughtered animals were bled and skinned. The head, four feet, skin, heart, liver, lungs, and internal fat were removed and weighed during dressing. After hot carcasses were weighed, the carcasses were chilled for 24 hours at +4°C and weighed. Testes, kidney, kidney and pelvic fat, and tail were removed and weighed. Afterward, the cold carcasses were split into two symmetrical parts along the backbone. The left half carcasses were divided into six different joints (leg, back-loin, forearm, shoulder, neck, flank-chest) as described by Colomer-Rocher et al. (1987) and weighed. The dressing percentage and proportional yields of wholesale cuts, organs, and fats in the carcass were determined by calculating from the obtained data. The area of the *musculus longissimus dorsi* (MLD) between the 12^{th} and 13^{th} vertebrae of the left half of the carcass was measured using a planimeter. In addition, the thickness of the subcutaneous fat over the area of the MLD was measured using a digital caliper.

2.4. Statistical analysis

Data for fattening performance, slaughter and carcass characteristics were analyzed by one-way analysis of variance using SAS (2022) package software.

3. Results and Discussion

3.1. Fattening performance

The mean and standard errors for the fattening performance of Akkaraman and (ASF x AK) F_1 lambs are given in *Table 2* and *Figure 1*. The initial live weight of Akkaraman and crossbred F_1 lambs were 23.89 kg and 23.77 kg, respectively. These values were higher than the values of 14.3-14.4 kg reported by Rodriguez et al. (2011) for Assaf and Merino x Assaf crossbred lambs and 20.06 kg and 21.58 kg reported by Khadre and Karabacak (2018) for Akkaraman and Awassi lambs. In addition, the initial weights of the lambs in this study were lower than 28.3-29.1 kg reported by Mateo et al. (2023) for Spanish Assaf lambs, but higher than those reported by Yaralı (2020) for different genotypes bred in Türkiye, which ranged from 19.70-22.50 kg. These variations in the initial live weight of lambs could be due to differences in genotype and starting time for fattening.

Live weights of pure and crossbred lambs were similar until day 42. Crossbreed F_1 (ASF x AK) lambs reached significantly ($p<0.01$) higher 56^{th} day and final (70^{th} day) live weights than Akkaraman lambs. Akkaraman and crossbreed F_1 lambs had final live weights of 41.02 kg and 44.03 kg, respectively, which was a statistically significant difference of 3.01 kg ($p<0.01$). Contrary to the study findings, Jawasreh et al. (2019) determined higher final live weight in Awassi x Rambouillet and Rambouillet x Awassi lambs (50.80 kg and 48.20 kg, respectively), but lower in Awassi lambs (37.10 kg). Additionally, Saro et al. (2020) noted that heavy fattening Assaf lambs had higher final live weights, ranging from 45.0 to 50.7 kg. Crossbreed F_1 (ASF x AK) and Akkaraman lambs gained 20.26 kg and 17.14 kg of total live weight, respectively, at the end of the finishing period ($p<0.01$). It was reported that Assaf lambs fed with two different agricultural wastes for 80 days gained a total weight of 17.9-19.5 kg (Abo Omar and Abdallah, 2019).

Table 2. Means and standard error (±s.e.) for fattening performance of Akkaraman and (ASF x AK) F_1 lambs

Traits	Akkaraman (n=10) $\bar{x} \pm S_{\bar{x}}$	(ASF x AK) F_1 (n=9) $\bar{x} \pm S_{\bar{x}}$
Initial live weight (kg)	23.89±0.26	23.77±0.24
14th day live weight (kg)	27.80±0.25	28.27±0.39
28th day live weight (kg)	31.82±0.39	31.89±0.55
42nd day live weight (kg)	35.27±0.60	36.47±0.56
56th day live weight (kg)	38.12±0.68	41.01±0.71**
Final live weight (kg)	41.02±0.76	44.03±0.65**
Total weight gain (kg)	17.14±0.91	20.26±0.51**
Average daily weight gain (kg)	0.245±0.013	0.289±0.007
Daily feed consumption (kg)	1.15	1.20
Feed conversion ratio	4.70	4.15

s.e.: standard error; **: p<0.01

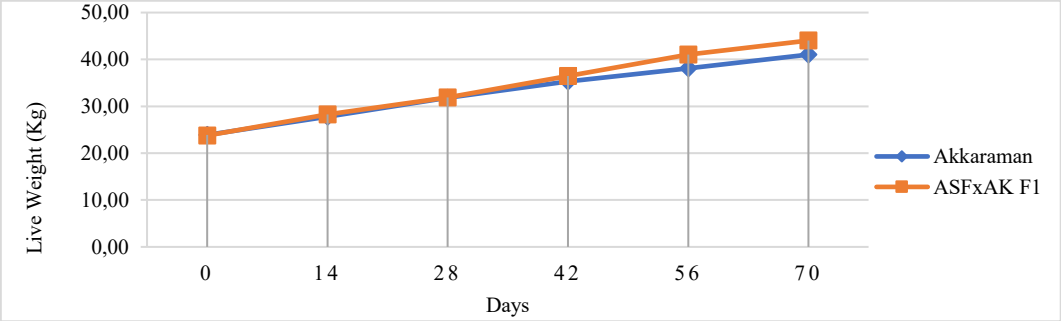

Figure 1. Live weight changes of Akkaraman and (ASF x AK) F_1 lambs on different fattening days

The average daily live weight gains of Akkaraman and (ASF x AK) F_1 lambs were found to be similar to the values in the range of 221-297 g/day determined in Assaf lambs by Saro et al. (2020). However, male lambs obtained from the crossbreeding of Akkaraman sheep with Hasak and Hasmer genotypes exhibited higher average daily live weight gain (Çolak et al., 2013). During fattening, daily concentrate intake was 1.15 kg for Akkaraman and 1.20 kg for (ASF x AK) F_1 lambs. Akkaraman and Bafra x Akkaraman B_1 crossbred lambs were found to consume similar amounts of concentrate feed during the intensive fattening (Güngör et al., 2022). The feed conversion ratio values obtained in this study were higher than those reported in Assaf and Merino x Assaf lambs by Rodriguez et al. (2011), Awassi-Rambouillet by Jawasreh et al. (2019), and Akkaraman, Bafra x F_1 (Bafra x Akkaraman) crossbred lambs by Güngör et al. (2022).

3.2. Body measurements of the lambs at fattening

Table 3 shows the mean values for body measurements of purebred and crossbred lambs during the fattening periods. Crossbred F_1 lambs had significantly greater withers height ($p<0.01$) and body length ($p<0.01$) than Akkaraman lambs at all stages of fattening. Akkaraman lambs had a significantly ($p<0.05$) greater chest width than (ASF x AK) F_1 lambs on days 28, 42, and 56, while crossbred lambs had a greater chest girth than purebred lambs on days 56 and 70 ($p<0.05$). There were no significant differences between breeds for leg circumference between days 0-28. On the other hand, the leg circumferences of Akkaraman and (ASF x AK) F_1 lambs were 38.10 cm and 40.56 cm ($p<0.01$) on day 42, 39.10 cm and 46.22 cm ($p<0.01$) on day 56, and 42.30 cm and 49.33 cm ($p<0.01$) on day 70, respectively. Contrary to the findings of this study, at the beginning of fattening, Aytekin et al. (2015) measured higher chest and leg circumferences in Akkaraman lambs, while Kutan and Keskin (2022) reported lower body measurement values in Awassi lambs. At the end of fattening, Akkaraman and (ASF x AK) F_1 lambs had a longer body length, a deeper chest, and a smaller leg circumference compared to Akkaraman, Awassi, Karayaka, and (Border Leicester x Karayaka) F_1 lambs (Dağ and Ertuğrul, 1993; Khadre and Karabacak, 2018).

Table 3. Body measurements (cm) of Akkaraman and* (ASF x AK) F_1 *lambs at different periods of the fattening

Traits	Akkaraman $\bar{x} \pm S_{\bar{x}}$	(ASF x AK) F_1 $\bar{x} \pm S_{\bar{x}}$
	0th day	
Withers height	57.20±0.53	59.78±0.28**
Body length	53.60±0.56	56.33±0.41**
Chest width	12.90±0.18	13.00±0.17
Chest depth	22.60±0.27	23.11±0.26
Chest girth	65.50±0.65	65.89±0.56
Leg circumference	33.20±0.33	33.56±0.38
	14th day	
Withers height	58.50±0.40	61.89±0.70**
Body length	54.70±0.34	59.11±0.54**
Chest width	13.70±0.15	13.67±0.24
Chest depth	23.40±0.27	24.22±0.36
Chest girth	66.80±0.53	67.11±0.70
Leg circumference	34.10±0.31	34.89±0.35
	28th day	
Withers height	62.20±0.49	64.33±0.37**
Body length	57.50±0.48	62.00±0.41**
Chest width	15.20±0.20*	14.33±0.37
Chest depth	24.90±0.23	25.11±0.45
Chest girth	71.10±0.23	70.67±0.69
Leg circumference	36.30±0.30	36.56±0.29
	42nd day	
Withers height	64.20±0.42	66.56±0.63**
Body length	59.00±0.54	63.44±0.56**
Chest width	16.30±0.26*	15.56±0.18
Chest depth	26.20±0.29	26.00±0.24
Chest girth	73.70±0.45	74.22±0.94
Leg circumference	38.10±0.23	40.56±0.41**
	56th day	
Withers height	66.20±0.51	68.78±0.49**
Body length	60.90±0.59	65.67±0.47**
Chest width	17.30±0.26*	16.33±0.33
Chest depth	27.30±0.21	27.56±0.44
Chest girth	75.10±0.48	78.22±1.16*
Leg circumference	39.10±0.57	46.22±0.62**
	70th day	
Withers height	68.10±0.48	70.44±0.50**
Body length	62.70±0.67	67.11±0.56**
Chest width	18.10±0.35	17.33±0.33
Chest depth	28.40±0.22	28.22±0.32
Chest girth	77.50±0.70	80.11±0.99*
Leg circumference	42.30±0.83	49.33±0.71**

*: $p<0.05$; **: $p<0.01$

3.3. Slaughter and carcass characteristics

Mean values for slaughter and carcass characteristics of Akkaraman and (ASF x AK) F_1 lambs are presented in *Table 4*. The mean slaughter weight of crossbred lambs was 44.34 kg, while that of purebred lambs was 39.22 kg ($p<0.05$). Similar to this study, Shaker et al. (2002) and Khadre and Karabacak (2018) reported that slaughter weight was significantly influenced by breed. Although hot and cold carcass weights of (ASF x AK) F_1 lambs were higher than Akkaraman lambs, only the difference in cold carcass weight was statistically significant ($p<0.05$). The hot and cold carcass weights of the lambs in this study were found to be higher than those of fattening studies with different genotypes (Rodriguez et al., 2008; 2011; Obeidat et al., 2019; Güngör et al., 2022).

Untailed cold carcass weight of (ASF x AK) F_1 lambs was significantly higher compared to Akkaraman lambs (19.22 kg vs. 15.86 kg, $p<0.01$). This result agreed with the findings reported by Karakuş (2007), who crossed two breeds with thin and fat tailed. Furthermore, the left carcass weights of (ASF x AK) F_1 lambs were considerably higher ($p<0.001$). Compared to Awassi lambs (8.47 kg), the left half carcass weight of (ASF x AK) F_1 lambs (9.41 kg) was higher (Khadre and Karabacak, 2018).

Table 4. Means and standard error for slaughter and carcass characteristics of Akkaraman and (ASF x AK) F_1 lambs

Traits	Akkaraman $\bar{x} \pm S_{\bar{x}}$	(ASF x AK) F1 $\bar{x} \pm S_{\bar{x}}$
Carcass weight (kg) and dressing percentage (%)		
Slaughter weight	39.22±1.62	44.34±0.53*
Hot carcass weight	20.24±0.78	22.00±0.28
Cold carcass weight	19.60±0.70	21.40±0.26*
Untailed cold carcass weight	15.86±0.61	19.22±0.24**
Left half carcass weight	7.20±0.24	9.41±0.34***
Dressing percentage	50.04±0.67	48.28±0.65
Untailed dressing percentage	40.47±0.56	43.37±0.67**
Cooling loss (%)	3.12±0.38	2.72±0.28
Weights of by-products and fat (kg)		
Head	2.10±0.06	2.33±0.05*
Feet	0.87±0.04	0.98±0.03*
Skin	3.78±0.25	4.79±0.16**
Heart+liver+lungs	1.54±0.05	1.97±0.04***
Testes	0.15±0.01	0.26±0.01***
Kidneys	0.12±0.01	0.12±0.01
Kidney+pelvic fat	0.05±0.01	0.18±0.03*
Internal fat	0.16±0.04	0.46±0.14
Tail fat	3.74±0.16***	2.18±0.08
Wholesale cuts of left half of carcass (kg)		
Leg weight	2.92±0.14	3.48±0.12**
Back-loin weights	1.00±0.09	1.23±0.07
Forearm weight	1.44±0.07	1.80±0.03**
Shoulder weight	0.44±0.04	0.60±0.07
Neck weight	0.56±0.07	0.62±0.06
Flank-chest weights	0.92±0.12	1.39±0.12**
M. longissimus dorsi (MLD) area (cm^2)	12.49±0.73	14.24±0.38
Fat thickness over MLD (mm)	2.92±0.24	2.19±0.28

*: $p<0.05$; **: $p<0.01$; ***: $p<0.001$

In terms of dressing percentage, although Akkaraman lambs had higher values than crossbred F_1 lambs, the share of tail fat weight, which had a significant difference at $p<0.001$ level, should not be ignored. In contrast to this study, Obeidat et al. (2019) found that dressing percentage was significantly influenced by breed. However, lower dressing percentage values were reported for Awassi, Chios x Awassi, Assaf, Merino x Assaf, Akkaraman and Bafra x Akkaraman B_1 lambs (Rodriguez et al., 2011; Obeidat et al., 2019, Güngör et al., 2022). Crossbred F_1 lambs had a significantly higher untailed dressing percentage than Akkaraman lambs, which was consistent with the results of the study reported by Karakuş (2007). Cooling loss in Akkaraman and (ASF x AK) F_1 lamb carcasses was 3.12% and 2.72%, respectively. Rodriguez et al. (2011) reported lower values for Assaf lambs, but cooling loss values of Merino x Assaf crossbred lambs were lower than Akkaraman lambs and similar to (ASF x AK) F_1 lambs.

As shown in *Table 4*, there were significant differences between the breeds in carcass by-product weights for all traits except weights of kidneys and internal fat. Crossbred F_1 lambs had higher head and feet weights than Akkaraman lambs at the $p<0.05$ significance level. Weights of skin, heart+liver+lungs, and testes were 3.78 kg and 4.79 kg ($p<0.01$), 1.54 kg and 1.97 kg ($p<0.001$), 0.15 and 0.26 kg ($p<0.001$) in Akkaraman and crossbred F_1 lambs, respectively. The difference observed in kidney+pelvic fat ($p<0.05$) and internal fat weights between Akkaraman and crossbred F_1 lambs may be due to the tendency of crossbred lambs to accumulate more fat in the body cavity, as their tail fat weight is lower. In contrast to the findings of this study, Ünal et al. (2006) reported no significant differences in head, feet, skin, heart+lungs+liver, kidney, and testis weights between purebred and crossbred genotypes. However, breed was found to have a significant effect on kidney+pelvic fat weight ($p<0.01$), as in this study.

Akkaraman lambs had a 1.56 kg heavier tail than Asaf lambs ($p<0.001$). Awassi, Awassi x Charollais, and Awassi x Romanov crossbred lambs had tail weights of 2.74 kg, 0.56 kg, and 0.43 kg ($p<0.001$) (Shaker et al., 2002). Similarly, crossbreeding with other breeds was found to reduce the weight of tail fat in Akkaraman breed (Ünal et al., 2006; Çolak et al., 2013).

Table 5. Proportional yields (%) (mean ± s.e.) of wholesale cuts, organs and fats in the carcass of Akkaraman and (ASF x AK) F_1 lambs

Traits	Akkaraman (n=5) $\bar{x} \pm S_{\bar{x}}$	(ASF x AK) F_1 (n=5) $\bar{x} \pm S_{\bar{x}}$
Head	5.37±0.18	5.26±0.13
Feet	2.22±0.12	2.22±0.06
Skin	9.61±0.34	10.81±0.41*
Heart+liver+lungs	3.94±0.09	4.44±0.09**
Testes	0.74±0.05	1.18±0.07***
Kidneys	0.59±0.02	0.56±0.01
Kidney+pelvic fat	0.26±0.02	0.82±0.15**
Internal fat	0.77±0.19	2.08±0.64
Tail fat	19.11±0.67***	10.19±0.33
Leg	40.52±0.95	37.13±1.50
Back-loin	13.11±1.03	13.10±0.57
Forearm	20.03±0.97	19.26±0.63
Shoulder	6.15±0.63	6.35±0.67
Neck	7.76±0.93	6.50±0.55
Flank-chest	12.78±1.64	14.73±1.07**

s.e.: standard error; *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$

Table 4 also shows the wholesale cuts from the left half of the carcasses. According to Rodriguez et al. (2011), the highest priced joints are leg, rib, and forelimb; the middle-priced joints are shoulder; and the lowest priced joints are breast, neck, and tail. Leg ($p<0.01$), forearm ($p<0.01$), and flank-chest ($p<0.01$) weights were

significantly greater in the (ASF x AK) F_1 crossbred lambs than in Akkaraman lambs. Obeidat et al. (2019) reported that shoulder and leg weights of Chios x Awassi lambs were significantly higher than those of Awassi lambs ($p<0.05$). The amount of muscle in the carcass, especially in the round and loin, is directly correlated with the MLD. Although the difference was not statistically significant, MLD area was higher in (ASF x AK) F_1 lambs (14.24 cm^2) than in Akkaraman lambs (12.49 cm^2). A lower MLD area was determined in Awassi and Chios x Awassi genotypes, but the effect of breed was significant (Obediat et al., 2019). On the other hand, higher backfat thickness was reported in Awassi lambs applied different fattening systems (Ceyhan et al., 2024) than in Akkaraman and (ASF x AK) F_1 crossbred lambs.

While the percentages of skin ($p<0.05$), heart+liver+lungs ($p<0.01$), testes ($p<0.001$), and kidney+pelvic fat ($p<0.01$) were significant in favor of F_1 lambs, the percentage of tail was statistically significant in Akkaraman lambs ($p<0.001$) (*Table 5*). The percentages of valuable carcass parts- leg, back-loin, forearm, shoulder, neck, and flank-chest- are required to be high. Although leg, forearm and neck percentages were higher in Akkaraman lambs than in crossbred F_1 lambs, the differences were not statistically significant. The flank-chest percentage of (ASF x AK) F_1 crossbred lambs was significantly higher than that of Akkaraman lambs ($p<0.01$). It has been reported that the use of Hasak and Hasmer genotypes in commercial crossbreeding with Akkaraman breed did not improve the leg, foreleg and rack percentages compared to purebred Akkaraman lambs (Çolak et al., 2013). On the other hand, significant effects of breed on the proportion of valuable carcass parts in different genotypes were reported by Yaralı (2020).

4. Conclusions

These results show that crossbreeding Akkaraman with Assaf breed gives positive results in terms of fattening performance and carcass quality, especially increasing carcass yield and the weights of carcass parts with high economic value. The use of the Assaf breed to improve meat yield traits in Akkaraman sheep is a recommended strategy to increase productivity and obtain higher quality carcasses. However, this superiority of crossbred lambs may be due to heterosis effect. Therefore, further studies using more comprehensive and different feeding regimes would be beneficial to confirm these results and demonstrate their wider applicability.

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Ethical Statement

This research and all experimental procedures were carried out in accordance with ethical standards approved by Van Yüzüncü Yil University Animal Experiments Local Ethics Committee (Approval no: 2022/08/19).

Conflicts of Interest

We declare that there is no conflict of interest between us as the article authors.

Authorship Contribution Statement

Concept: Oramari, R. A. S., Karakuş, F.; Design: Oramari, R. A. S., Karakuş, F.; Data Collection or Processing: Al-Barwari, I. I. I.; Statistical Analyses: Oramari, R. A. S., Karakuş, F.; Literature Search: Al-Barwari, I. I. I.; Writing, Review and Editing: Oramari, R. A. S., Karakuş, F.

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