



Evaluation of the genotype and slaughter weight effect on the meat production traits: Comparison of fattening, slaughter, and carcass characteristics between two native sheep

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ABSTRACT

The aim of this study was to evaluate the effect of genotype [purebred Akkaraman (AKK), BA B₁ crossbred Bafra×F₁ (Bafra×AKK)] and slaughter weight (SW) (35, 40, and 45 kg) on fattening, slaughter, and carcass characteristics. A total of 46 lambs were used in this study. Feed conversion ratios were affected by genotype ($P < 0.001$) and SW ($P = 0.015$). Hot ($P = 0.003$) and chilled ($P = 0.021$) dressing percentages based on empty body weight were affected by genotype. Genotype and SW affected the percentage of the head ($P < 0.001$ and $P < 0.001$), feet ($P = 0.012$ and $P = 0.014$), lungs ($P = 0.022$ and $P = 0.043$), testicles ($P < 0.001$ and $P = 0.002$), omental fat ($P < 0.001$ and $P = 0.012$), mesenteric fat ($P < 0.001$ and $P < 0.001$), and the length of the carcass ($P = 0.006$ and $P < 0.001$) and the back ($P < 0.001$ and $P = 0.010$). In addition, leg circumference ($P = 0.008$ and $P < 0.001$), the compactness indices of the carcass ($P = 0.024$ and $P < 0.001$) and the leg ($P = 0.030$ and $P < 0.001$), and the bone ratio of the back ($P < 0.001$ and $P = 0.019$) and the loin ($P = 0.027$ and $P < 0.001$) were significantly affected by genotype and SW groups. In conclusion, genotype and SW affected some fattening, slaughter, and carcass traits, and it drew attention that the effect of SW on carcass measures and the effect of genotype on the ratios of individual cuts were usually significant.

1. Introduction

It is well known that sheep is an important meat source for the arid and semi-arid regions because of the efficiency of using the low-quality forages. In general, sheep breeding is more prevalent in semi-arid regions, and lamb meat production usually is the primary function of the sheep industry in these regions; therefore, the improvement of the lamb fattening, slaughter, and carcass traits will be an important effect on meat production in these regions (Abdullah et al., 2010; Ates et al., 2020; Cadavez et al., 2020). Pure breeding and crossbreeding are two ways to improve animal performance traits, but improvement of the genetic value by pure breeding takes a long time. Therefore, commercial crossbreeding programs and upgrading programs were more preferable for higher performance yields in short periods (Akçapınar, 2000).

AKK and BA B₁ were used as genotypes in this study. AKK is the most common sheep breed in Türkiye due to its good adaptation ability, high

growth performance, and survival rate. Bafra sheep having enough milk performance, high meat quality, and reproductive performance is a synthetic breed and was obtained by crossbreeding with Chios (75 %) and Karayaka (25 %) breeds in 1982 (Akçapınar et al., 2005; Yakan and Ünal, 2010a). BA B₁ genotype was developed to use both in pure breeding and crossbreeding to increase lamb meat production. Therefore, the BA B₁ genotype was obtained for a combination of the different desirable production traits of Bafra and AKK sheep breeds. Firstly, Bafra ram was mated with AKK ewes and obtained BA F₁ ewes, and then BA F₁ ewes were backcrossed with Bafra rams for obtaining of BA B₁ genotype (Bafra 75 % and AKK 25 %) (Güngör and Ünal, 2020).

The meat industry demands a certain quality and standard of meat and carcass such as leaner meat, less bone, and less fat (an adequate fat level necessary to maintain juiciness and flavor) (Abdullah and Qudsieh, 2009; Ates et al., 2020; Ramírez-Retamal e Morales, 2014). Sheep producers, on the other hand, want to produce meat and carcass conforming

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to these standards at minimum cost. These demands of producers and consumers related to the fattening, slaughter, and carcass characteristics of lambs are affected by genotype and environmental factors (Abdullah et al., 2010; Sañudo et al., 1997; Teke and Ünal, 2009; Žgur, 2003). Sheep breeders need proper genotypes and breeding programs to obtain these standards in their farm conditions. The SW is one of the environmental factors, and the determination of the SW and genotype effects on the fattening, slaughter, and carcass traits will contribute to these needs of breeders. Therefore, this study aimed to evaluate the genotype and SW of the fattening, slaughter, and carcass characteristics of lambs using the pure AKK and crossbreed BA B₁ genotypes.

2. Material and methods

2.1. Geographical location, animals, and fattening period

This study was performed at Gözülü state farm having 20,000 sheep. This farm is in the central Anatolia region of Türkiye and located at 38° 29' N and 32° 27' E, 1020 m above sea level. The lambs were randomly sampled from two flocks, each flock consisting of 500 ewes. Flock mating has been applied for the mating, and 25 rams have been used for each flock. The length of lambing season is about 50 days, but most births (~75 %) occur in the first 30 days. The lamb sampling did from the lambs between 17 and 23 kg after 70 days at the beginning of the lambing period. A total of 46 male lambs (23 AKK and 23 BA B₁) were used in this study. The min and max weights of AKK and BA B₁ lambs were 17.66–22.78 and 17.05–23.03 kg, respectively. At the beginning of the study, drugs against internal and external parasites were applied to the lambs. The lambs separated according to the genotype were housed in pens inside (2 m² per lamb) and outside (5 m² per lamb) place and fed with ad libitum concentrate feed (15 % crude protein and 2800 kcal/kg ME) and 300 g alfalfa hay for each animal per day. All lambs had free access to potable water and natural mineral block. Lambs were daily observed in terms of feeding and health problems. The fattening period continued for 94 days, but the first ten days of this period were the dietary adaptation period. One of the AKK lambs had a health problem in the adaptation period therefore this lamb was excluded from the study and was treated.

The fattening was continued until the 35, 40, and 45 kg live weight, and the six animals were sacrificed from each genotype according to the SW groups for the determination of the slaughter and carcass characteristics. During the fattening period, the following records were collected: Initial and final date of the fattening period, Initial and final weight of animals (kg), every 14 days weighing of the lambs, and daily feed consumption of the lambs. However, lambs approaching the SW were weighed every other day or every day to determine the exact SW. When the lambs reached an average of 35 kg live weight in the genotype groups, six lambs from each genotype were randomly selected for the 35 kg SW group. The same procedure was applied when the rest of the lambs reached a mean live weight of 40 and 45 kg.

2.2. Slaughtering and carcass characteristics

Every animal was weighted 12 h before slaughter (final weight), and before slaughter for fasting weight (slaughter weight). After bleeding, non-carcass components (head, skin, feet, heart, lungs, liver, spleen, testicles, penis-preputium, full digestive tract, empty rumen, empty intestine, trachea-esophagus, omental fat, and mesenteric fat) except for kidneys and perinephric–pelvic fat were removed, and all these components and hot carcass weighed and recorded. The carcass measurements were taken as follows:

Carcass length: between the caput humeri and tuber ischii,

Back length: between the dorsal cranial point of the shoulder and dorsal cranial point of the tail,

Leg internal length: between the cranial edge of the symphysis pubis and the tarsal–metatarsal joint,

Leg external length: between the articulatio coxae and the tarsal–metatarsal joint,

Rump length: between the tuber coxae and tuber ischii,

Neck length: between the dorsal cranial point of the shoulder and cranial point of the neck,

Leg circumference: over the articulationes coxae on the carcass,

Chest girth: over the caudal points of the scapulas,

Rump girth: over the articulationes coxae,

Leg width: distance between the two gigots at the junction point alignment of legs,

Chest width: distance between the left and right of the extremitas proximalis scapulas,

Rump width: distance between the articulationes coxae,

Chest depth: distance between the sternum and the withers,

Carcass compactness index: cold carcass weight/carcass length; kg/m (Santos et al., 2007),

Leg compactness index: leg weight/leg length; kg/m (Santos et al., 2007).

The weight of the gastrointestinal tract contents was calculated by deducting the empty rumen and intestine from the full digestive tract, and these values were deducted from the final SW, so the empty body weight was calculated. The percentage of the hot and cold dressing was calculated and presented according to the slaughter and empty body weights.

Carcasses were chilled for 24 h at 4 °C and weighted for cold carcass weight. Tail fat, kidneys, and perinephric–pelvic fat were removed and weighed. After that, the cold carcasses were longitudinally cut along the vertebral column and these two half carcasses were weighted. The left side half carcasses were cut into six cuts according to Akçapınar (1981) and grouped according to Díaz et al. (2006). The definitions of these cut groups were taken as follows.

Leg: removed leg by cutting from the cranial of the last lumbar vertebra,

Foreleg: removed foreleg by cutting through the synsarcosis joint,

Back: consisting of the last 8 thoracic vertebrae and the first 10 cm parts of the rib,

Loin: consisting of the first 5 lumbar vertebrae,

Neck: consisting of the 7 cervical and first 5 thoracic vertebrae and the first 10 cm parts of the rib,

Breast + Flank: removed the breast+flank by cutting 10 cm distal to the vertebrae,

First quality: sum of the leg, back, and loin,

Second quality: foreleg,

Third quality: sum of neck and breast+flank.

M. longissimus thoracis et lumborum area (ribeye area cm²) was drawn onto the acetate between the 12th and 13th rib after 24 h from slaughter, and its surface area was calculated using the AutoCAD software (version 2019). In addition, the fat depth was measured with a caliper in this region. After that, each section of the left carcasses was weighted, and these sections were dissected and weighted as lean, bone, fat, and remainder (Fisher and de Boer, 1994). The dissection started after 24 h from slaughter and finished in the 5 h for each half carcass. Two people (a veterinary and a butcher) checking each other in terms of dissection did the dissection according to Fisher and de Boer (1994).

2.3. Statistical analyses

Data collected for each genotype and SW group were analyzed using the Least Squares Mixed Model procedures of SPSS software (SPSS Software, 2005) to determine the influence of genotype and SW on the fattening, slaughter, and carcass characteristics. The analytical model was given as follows:

$$y_{ijk} = \mu + \text{anim}_i + G_j + \text{SW}_k + G_j \times \text{SW}_k + e_{ijk}$$

The y_{ijk} refers to each trait, μ the overall mean, anim_i the random

effect of the i^{th} animal, G_j the fixed effect of j^{th} genotype (BA B₁ and AKK), SW_k the fixed effect of the k^{th} slaughter weight (35, 40, and 45 kg), and e_{ijk} the residual component of the model. A covariance matrix for the random effect of animals was assumed as a simple variance components structure and estimated using the restricted maximum likelihood method. Posthoc testing for significant interactions was performed using simple effect analysis with the LSD adjustment. In cases where the interaction term was not statistically significant, Tukey's multiple comparison test was used to analyse the main effects. A probability value of less than 0.05 was considered significant. For the lean percentage of the loins cuts, pairwise comparison of the genotype and the differences among the SW groups were analyzed by t-test and one-way ANOVA with Tukey's HSD test, respectively.

3. Results

Study results were presented in the five sections and tables. Generally, no significant interactions were found ($P > 0.05$) between the genotype and SW groups, except for bone ratio in the loin.

3.1. Fattening traits

Means of fattening performance traits were presented in Table 1. The initial and final live weight of genotypes were similar because the initial and final live weight of lambs were determined according to the study protocol. Statistically significant differences were determined among the SW groups for the initial weights ($P = 0.009$), the times of fattening ($P = 0.001$), final weights ($P < 0.001$), average daily weight gain values ($P < 0.001$), and feed conversion ratios ($P = 0.015$). Daily concentrate feed intake (kg) and feed conversion ratio values between the genotypes were significant.

3.2. Slaughter characteristics

Means of slaughter characteristics were given in Table 2. Genotype did not impact the SW, empty body weights, carcass weights, and dressing ratios based on SW except for dressing ratios based on empty body weight because the empty body weight differentiation between the genotypes were close to the significant point. Head ($P < 0.001$), feet ($P = 0.012$), full digestive ($P = 0.031$) and empty digestive tract ($P = 0.029$) ratios of AKK lambs were significantly higher than those of BA B₁ lambs while lungs ($P = 0.022$), liver ($P = 0.027$), testicles ($P < 0.001$), omental ($P = 0.001$) and mesenteric ($P < 0.001$) fat ratios of BA B₁ were significantly higher than those of AKK. As a result of carcass weight increase, the head ($P < 0.001$), skin ($P = 0.033$), feet ($P = 0.014$), lungs ($P = 0.043$), testicles ($P = 0.002$), omental ($P = 0.012$), and mesenteric ($P = 0.001$) fat ratios have significantly raised.

3.3. Carcass measurements and indices

Results of carcass measurements and indices were shown in Table 3.

Table 1
Means ($\pm$ SE) of fattening performance.

Items	Genotype		SW Groups			P values		
	AKK (n: 22)	BA B ₁ (n: 23)	35 kg (n: 45)	40 kg (n: 33)	45 kg (n: 21)	G	SW	G×SW
Initial weight (kg)	20.46 $\pm$ 0.37	20.37 $\pm$ 0.37	19.67 $\pm$ 0.48 ^a	20.02 $\pm$ 0.26 ^a	21.56 $\pm$ 0.46 ^b	0.854	0.009	0.915
The time of fattening (days)	76.92 $\pm$ 2.17	79.22 $\pm$ 2.43	70.39 $\pm$ 2.80 ^a	79.82 $\pm$ 1.76 ^b	84.01 $\pm$ 2.27 ^b	0.401	0.001	0.479
Final weight (kg)	42.30 $\pm$ 0.98	42.29 $\pm$ 0.99	37.31 $\pm$ 0.25 ^a	42.53 $\pm$ 0.25 ^b	47.05 $\pm$ 0.18 ^c	0.992	< 0.001	0.181
Average daily weight gain (g)	283.98 $\pm$ 8.10	276.40 $\pm$ 6.15	252.49 $\pm$ 7.28 ^a	282.97 $\pm$ 5.04 ^b	305.10 $\pm$ 8.84 ^b	0.326	< 0.001	0.378
Daily concentrate feed intake (kg)	1.18 $\pm$ 0.00	1.10 $\pm$ 0.00	1.14 $\pm$ 0.01	1.14 $\pm$ 0.01	1.14 $\pm$ 0.01	< 0.001	0.762	0.437
Feed conversion ratio*	4.02 $\pm$ 0.01	3.97 $\pm$ 0.01	4.03 $\pm$ 0.02 ^b	3.99 $\pm$ 0.01 ^a	3.98 $\pm$ 0.01 ^a	< 0.001	0.015	0.561

AKK: Akkaraman, BA B₁: The backcrossing of the BA (Bafra×AKK) F1 dams to the Bafra sire line, SE: Standard error, SW: Slaughter weight, G: genotype, SW×G: two-way interaction of genotype and SW, a, b, c: means with unlike letters in rows differ significantly ($P < 0.05$).

*: Concentrate feed consumed (kg) for 1 kg body weight gain.

BA B₁ lambs had significantly longer carcass length ($P = 0.006$), back length ($P < 0.001$), and chest width ($P = 0.030$), than AKK lambs while AKK lambs had higher leg circumference ($P = 0.008$), carcass and leg compactness indices ($P = 0.024$ and $P = 0.030$), than BA B₁ lambs. As a result of carcass weight increase, carcass length ($P < 0.001$), back length ($P = 0.010$), leg external length ($P = 0.002$), leg circumference ($P < 0.001$), chest girth ($P < 0.001$), rump girth ($P < 0.001$), rump width ($P < 0.001$), chest depth ($P < 0.001$), carcass and leg compactness indices ($P < 0.001$) values have significantly increased.

3.4. Carcass cuts and composition

The evolution of individual cuts and the composition of the carcass is presented in Table 4. Genotype had a significant effect on the individual cuts in the carcass ratios except for leg and foreleg sections, but SW did not have a significant effect on the individual cuts in the carcass ratios except for the leg section. BA B₁ lambs had higher third quality and fat ratio and lower lean/fat ratio in the carcass than AKK. It should not, however, be forgotten that the tail ratio of AKK in the carcass was three times higher than BA B₁ lambs. First quality and bone ratio in the carcass were significantly higher in the 35 and 40 kg SW groups than those of the 45 kg SW group. Ribeye area significantly increased ($P = 0.013$) with increasing SW.

3.5. Composition of carcass cuts

The composition of the carcass cuts is given in Table 5. The fat percentages in the leg ($P = 0.002$), back ($P = 0.001$), neck ($P = 0.001$), and breast+flank ($P = 0.025$) of BA B₁ lambs were significantly higher than those of AKK lambs, while lean and bone percentage in the leg ($P = 0.023$ and $P = 0.037$), and neck ($P = 0.027$ and $P = 0.008$) of the AKK lambs were significantly higher than those of BA B₁ lambs. The bone percentages in the back and loin were significantly affected by genotype ($P = 0.001$ and $P = 0.037$) and SW ($P = 0.019$ and $P < 0.001$). Even though the fat percentages in all cuts increased with increasing the SW, there was no significant difference among the SW groups for fat percentages in all cuts. The bone percentages in the loin cuts according to the genotype and SW groups are given in Table 6 because significant interactions were found ($P > 0.05$) between the genotype and SW groups for the bone percentage in the loin. According to these comparisons, the BA B₁ genotype in 45 kg SW had a significantly lower bone ratio than those of 35 and 40 kg SWs of BA B₁ ($P < 0.001$) and 45 kg of AKK genotype ($P = 0.009$).

4. Discussion

4.1. Fattening traits

Fattening traits are generally affected by genotype (Abdullah et al., 2010; Al Khewani et al., 2014; Vargas Junior et al., 2019). In this study, even though AKK had a similar average daily weight gain (283.98 g) to

Table 2

Means (± SE) of slaughter characteristics (n: 18 for each genotype, and n: 12 for each SW group).

Items	Genotype		SW Groups			P values		
	AKK	BA B ₁	35 kg	40 kg	45 kg	G	SW	G×SW
Slaughter weight (kg)	41.38 ± 0.93	41.11 ± 0.92	36.66 ± 0.28 ^a	41.24 ± 0.16 ^b	45.83 ± 0.22 ^c	0.291	< 0.001	0.250
Empty body weight (kg)	37.77 ± 0.98	38.56 ± 1.02	33.13 ± 0.38 ^a	38.56 ± 0.47 ^b	42.80 ± 0.27 ^c	0.059	< 0.001	0.055
Hot carcass weight (kg)	19.84 ± 0.54	19.50 ± 0.52	17.22 ± 0.29 ^a	19.55 ± 0.17 ^b	22.24 ± 0.23 ^c	0.204	< 0.001	0.186
Cold carcass weight (kg)	19.14 ± 0.52	18.84 ± 0.51	16.65 ± 0.32 ^a	18.92 ± 0.21 ^b	21.40 ± 0.26 ^c	0.312	< 0.001	0.094
Hot dressing ^A (%)	47.89 ± 0.44	47.39 ± 0.47	46.97 ± 0.65	47.41 ± 0.36	48.54 ± 0.55	0.435	0.129	0.564
Hot dressing ^B (%)	52.53 ± 0.44	50.60 ± 0.41	51.96 ± 0.49	50.77 ± 0.66	51.97 ± 0.56	0.003	0.188	0.938
Chilled dressing ^A (%)	46.21 ± 0.49	45.79 ± 0.55	45.42 ± 0.78	45.87 ± 0.49	46.71 ± 0.61	0.567	0.365	0.327
Chilled dressing ^B (%)	50.70 ± 0.55	48.88 ± 0.48	50.25 ± 0.67	49.12 ± 0.74	50.01 ± 0.63	0.021	0.441	0.856
Non-carcass components (as % of SW)								
Head	4.34 ± 0.06	5.12 ± 0.06	4.91 ± 0.13 ^b	4.76 ± 0.13 ^b	4.52 ± 0.13 ^a	< 0.001	< 0.001	0.795
Skin	11.82 ± 0.23	12.34 ± 0.35	11.57 ± 0.24 ^a	11.86 ± 0.34 ^{ab}	12.81 ± 0.42 ^b	0.182	0.033	0.253
Feet	2.47 ± 0.04	2.34 ± 0.04	2.50 ± 0.04 ^b	2.39 ± 0.05 ^{ab}	2.31 ± 0.06 ^a	0.012	0.014	0.100
Heart	0.44 ± 0.01	0.43 ± 0.01	0.46 ± 0.01	0.43 ± 0.01	0.42 ± 0.02	0.557	0.126	0.220
Lungs	1.41 ± 0.05	1.56 ± 0.05	1.37 ± 0.04 ^a	1.55 ± 0.05 ^b	1.54 ± 0.07 ^b	0.022	0.043	0.880
Liver	2.04 ± 0.04	2.17 ± 0.03	2.09 ± 0.04	2.09 ± 0.06	2.13 ± 0.04	0.027	0.751	0.389
Spleen	0.23 ± 0.01	0.27 ± 0.02	0.27 ± 0.03	0.25 ± 0.02	0.23 ± 0.02	0.108	0.315	0.541
Testicles	0.35 ± 0.02	0.68 ± 0.03	0.43 ± 0.05 ^a	0.56 ± 0.06 ^b	0.55 ± 0.06 ^b	< 0.001	0.002	0.517
Penis and Preputium	0.11 ± 0.01	0.13 ± 0.01	0.13 ± 0.01	0.12 ± 0.01	0.11 ± 0.01	0.193	0.356	0.215
Full digestive tract	19.97 ± 0.56	18.27 ± 0.56	20.24 ± 0.75	18.90 ± 0.79	18.23 ± 0.54	0.031	0.101	0.220
Empty rumen	3.00 ± 0.10	2.88 ± 0.05	3.02 ± 0.10	3.03 ± 0.10	2.77 ± 0.07	0.271	0.096	0.525
Empty intestine	4.54 ± 0.19	3.99 ± 0.13	4.28 ± 0.24	4.44 ± 0.25	4.09 ± 0.14	0.029	0.499	0.701
Trachea+Esophagus	0.22 ± 0.01	0.22 ± 0.01	0.23 ± 0.01	0.21 ± 0.01	0.22 ± 0.01	0.869	0.435	0.140
Omental fat	0.56 ± 0.04	1.18 ± 0.08	0.71 ± 0.10 ^a	0.86 ± 0.10 ^{ab}	1.03 ± 0.14 ^b	< 0.001	0.012	0.193
Mesenteric fat	0.87 ± 0.04	1.04 ± 0.04	0.83 ± 0.04 ^a	0.95 ± 0.05 ^{ab}	1.08 ± 0.05 ^b	0.001	0.001	0.683
Kidneys ^C	0.35 ± 0.01	0.35 ± 0.01	0.35 ± 0.01	0.36 ± 0.01	0.35 ± 0.01	0.606	0.628	0.312
Back fat depth (mm)	2.19 ± 0.16	2.25 ± 0.20	1.94 ± 0.21	2.22 ± 0.22	2.50 ± 0.22	0.825	0.219	0.548

AKK: Akkaraman, BA B₁: The backcrossing of the BA (Bafra×AKK) F1 dams to the Bafra sire line, SE: Standard error, SW: Slaughter weight, G: genotype, SW×G: two-way interaction of genotype and SW, a, b, c: means with unlike letters in rows differ significantly (P < 0.05).

^A: Based on SW

^B: Based on empty body weight

^C: Based on chilled carcass weight

Table 3

Means (± SE) for carcass measurements and indices (n: 18 for each genotype, and n: 12 for each SW group).

Items	Genotype		SW Groups			P values		
	AKK	BA B ₁	35 kg	40 kg	45 kg	G	SW	G×SW
Carcass length (cm)	79.67 ± 0.64	81.75 ± 0.72	78.08 ± 0.60 ^a	81.00 ± 0.64 ^b	83.04 ± 0.75 ^b	0.006	< 0.001	0.907
Back length (cm)	57.53 ± 0.52	61.36 ± 0.84	57.42 ± 1.02 ^a	60.38 ± 0.84 ^b	60.54 ± 0.97 ^b	< 0.001	0.010	0.361
Leg internal length (cm)	26.69 ± 0.33	27.53 ± 0.27	27.00 ± 0.36	27.04 ± 0.40	27.29 ± 0.42	0.063	0.838	0.250
Leg external length (cm)	40.56 ± 0.43	40.92 ± 0.34	39.67 ± 0.51 ^a	40.71 ± 0.43 ^{ab}	41.83 ± 0.22 ^b	0.430	0.002	0.107
Rump length (cm)	8.17 ± 0.39	7.83 ± 0.34	7.83 ± 0.53	8.08 ± 0.50	8.08 ± 0.33	0.538	0.908	0.379
Neck length (cm)	16.28 ± 0.28	15.39 ± 0.36	15.79 ± 0.44	15.460.35	16.250.43	0.060	0.372	0.463
Leg circumference (cm)	49.28 ± 0.79	47.31 ± 0.69	45.46 ± 0.96 ^a	48.42 ± 0.43 ^b	51.00 ± 0.54 ^c	0.008	< 0.001	0.099
Chest girth (cm)	73.47 ± 0.56	74.11 ± 0.92	70.96 ± 1.02 ^a	74.21 ± 0.53 ^b	76.21 ± 0.37 ^b	0.439	< 0.001	0.477
Rump girth (cm)	58.06 ± 0.70	57.83 ± 0.68	55.50 ± 0.71 ^a	58.04 ± 0.50 ^b	60.29 ± 0.64 ^c	0.759	< 0.001	0.264
Leg width (cm)	17.44 ± 0.68	17.17 ± 0.52	16.83 ± 0.80	16.63 ± 0.19	18.46 ± 0.92	0.738	0.156	0.251
Chest width (cm)	17.14 ± 0.28	18.61 ± 0.60	17.96 ± 0.94	17.33 ± 0.30	18.33 ± 0.36	0.030	0.452	0.168
Rump width (cm)	17.61 ± 0.26	17.30 ± 0.25	16.54 ± 0.25 ^a	17.38 ± 0.15 ^b	18.46 ± 0.24 ^c	0.240	< 0.001	0.728
Chest depth (cm)	27.33 ± 0.21	27.64 ± 0.26	26.67 ± 0.24 ^a	27.63 ± 0.20 ^b	28.17 ± 0.25 ^b	0.269	< 0.001	0.873
Carcass compactness index	23.99 ± 0.53	23.02 ± 0.52	21.34 ± 0.44 ^a	23.36 ± 0.21 ^b	25.81 ± 0.46 ^c	0.024	< 0.001	0.208
Leg compactness index	7.34 ± 0.12	7.04 ± 0.14	6.65 ± 0.17 ^a	7.31 ± 0.09 ^b	7.60 ± 0.09 ^b	0.030	< 0.001	0.165

AKK: Akkaraman, BA B₁: The backcrossing of the BA (Bafra×AKK) F1 dams to the Bafra sire line, SE: Standard error, SW: Slaughter weight, G: genotype, SW×G: two-way interaction of genotype and SW, a, b: means with unlike letters in rows differ significantly (P < 0.05).

BA B₁ lambs (276.40 g), AKK had significantly greater daily concentrate feed intake (1.18 kg) and a lower feed conversion ratio (4.02) than those of BA B₁ lambs (1.10 kg and 3.97). These results agree with Unal et al., (2006) who found AKK had more feed intake (daily concentrate feed intake: 1.398 kg), higher daily weight gain (284 g), and lower feed conversion ratio (4.921) than its crossbreeds (Kıvrık x AKK F₂, Kıvrık x AKK B₁, and Chios x AKK F₂). Yaranoglu and Özbeyaz, (2020), however, reported a higher average daily weight gain (356 g) and a better feed conversion ratio (3.11) for AKK. The poorer feed conversion ratio observed for AKK compared to BA B₁ agrees with their total fat ratio because AKK and BA B₁ carcasses had 12.21 % and 4.63 % tail fat ratios, 1.15 % and 1.99 % perinephric–pelvic fat ratios, and 10.66 % and 16.19

% fat ratios, respectively. It is calculated that the total fat ratio in the AKK carcasses had 1.21 % higher than BA B₁ lambs, and it is known that energy requirement is higher for fat deposition than lean deposition. In addition, similar differences owing to the hybrid vigor between the pure and crossbreed in terms of feed conversion ratio were reported by several researchers (Abdullah et al., 2010; Al Khewani et al., 2014; Vargas Junior et al., 2019).

The initial weight of the 45 kg SW group was significantly higher than those of the 35 and 40 kg groups because there was a tendency to leave the lambs having a high initial weight to the 45 kg SW group. The lambs slaughtered at 40 and 45 kg SW had better average daily weight gain (282.97 and 305.10 g) and feed conversation ratio (3.98 and 3.98)

Table 4

Means (± SE) for individual cuts and composition of the carcass (n: 18 for each genotype, and n: 12 for each SW group).

Items	Genotype		SW Groups			P values		
	AKK	BA B ₁	35 kg	40 kg	45 kg	G	SW	G×SW
<i>Individual cuts in the carcass (out of 100)</i>								
Leg	31.25 ± 0.45	30.67 ± 0.32	31.68 ± 0.58 ^b	31.45 ± 0.25 ^b	29.75 ± 0.34 ^a	0.223	0.003	0.187
Foreleg	16.39 ± 0.54	16.94 ± 0.39	16.39 ± 0.65	17.41 ± 0.63	16.20 ± 0.38	0.429	0.309	0.939
Back	7.40 ± 0.29	8.33 ± 0.25	7.80 ± 0.30	7.84 ± 0.39	7.96 ± 0.40	0.019	0.937	0.104
Loin	7.95 ± 0.23	8.72 ± 0.32	8.22 ± 0.42	8.84 ± 0.33	7.94 ± 0.27	0.052	0.156	0.206
Neck	12.15 ± 0.39	15.44 ± 0.52	13.75 ± 0.77	13.26 ± 0.53	14.37 ± 0.88	< 0.001	0.394	0.478
Breast+Flank	11.49 ± 0.33	13.28 ± 0.52	12.51 ± 0.71	11.89 ± 0.34	12.75 ± 0.67	0.007	0.514	0.325
Tail	12.21 ± 0.66	4.63 ± 0.34	8.25 ± 1.08	7.67 ± 1.33	9.35 ± 1.46	< 0.001	0.177	0.508
Perinephric–pelvic fat	1.15 ± 0.04	1.99 ± 0.11	1.40 ± 0.14	1.63 ± 0.16	1.67 ± 0.18	< 0.001	0.121	0.380
<i>Category</i>								
First quality	46.60 ± 0.43	47.72 ± 0.63	47.70 ± 0.58 ^b	48.13 ± 0.65 ^b	45.65 ± 0.60 ^a	0.093	0.008	0.052
Second quality	16.39 ± 0.54	16.94 ± 0.39	16.39 ± 0.65	17.41 ± 0.63	16.20 ± 0.38	0.429	0.309	0.939
Third quality	23.65 ± 0.59	28.72 ± 0.58	26.26 ± 1.08	25.16 ± 0.77	27.13 ± 1.19	< 0.001	0.127	0.091
<i>Composition of the carcass (out of 100)</i>								
Lean	50.44 ± 0.97	51.38 ± 0.79	51.73 ± 0.93	51.77 ± 0.99	49.23 ± 1.22	0.456	0.183	0.837
Bone	17.89 ± 0.42	17.74 ± 0.41	18.80 ± 0.39 ^b	18.09 ± 0.32 ^b	16.54 ± 0.54 ^a	0.765	0.003	0.319
Fat	10.66 ± 0.89	16.19 ± 0.83	12.25 ± 1.22	13.05 ± 1.08	14.96 ± 1.58	< 0.001	0.162	0.187
Remainder	7.67 ± 0.35	8.06 ± 0.38	7.57 ± 0.41	7.78 ± 0.31	8.24 ± 0.58	0.460	0.575	0.731
Lean/Fat	5.38 ± 0.50	3.35 ± 0.21	4.77 ± 0.54	4.49 ± 0.61	3.84 ± 0.51	0.001	0.384	0.913
Lean/Bone	2.84 ± 0.07	2.92 ± 0.06	2.77 ± 0.08	2.87 ± 0.07	3.00 ± 0.09	0.429	0.154	0.690
Ribeye area (cm ²)	10.70 ± 0.26	11.08 ± 0.28	10.17 ± 0.21 ^a	10.99 ± 0.30 ^{ab}	11.51 ± 0.36 ^b	0.278	0.013	0.698

AKK: Akkaraman, BA B₁: The backcrossing of the BA (Bafra×AKK) F1 dams to the Bafra sire line, SE: Standard error, SW: Slaughter weight, G: genotype, SW×G: two-way interaction of genotype and SW, a, b: means with unlike letters in rows differ significantly (P < 0.05).

Table 5

Means (± SE) for the composition of the carcass cuts (%) (n: 18 for each genotype, and n: 12 for each SW group).

Items	Genotype		SW Groups			P Values		
	AKK	BA B ₁	35 kg	40 kg	45 kg	G	SW	G×SW
<i>Leg</i>								
Lean	62.09 ± 0.83	59.31 ± 0.73	61.28 ± 0.97	60.37 ± 1.06	60.45 ± 1.10	0.023	0.780	0.931
Bone	19.43 ± 0.39	18.41 ± 0.27	19.44 ± 0.42	19.08 ± 0.36	18.25 ± 0.47	0.037	0.121	0.769
Fat	11.59 ± 0.77	15.50 ± 0.75	12.90 ± 1.01	13.85 ± 1.00	13.88 ± 1.28	0.002	0.725	0.922
Remainder	6.89 ± 0.50	6.78 ± 0.42	6.38 ± 0.66	6.70 ± 0.57	7.42 ± 0.43	0.878	0.453	0.974
<i>Foreleg</i>								
Lean	60.88 ± 1.49	59.05 ± 0.67	59.16 ± 2.09	61.05 ± 1.01	59.68 ± 0.91	0.279	0.635	0.449
Bone	19.95 ± 0.58	19.99 ± 0.47	20.43 ± 0.90	19.73 ± 0.27	19.76 ± 0.61	0.961	0.715	0.940
Fat	9.89 ± 2.30	12.43 ± 0.81	12.26 ± 3.38	10.04 ± 1.05	11.17 ± 1.22	0.322	0.775	0.572
Remainder	9.28 ± 0.51	8.53 ± 0.51	8.15 ± 0.81	9.18 ± 0.53	9.39 ± 0.49	0.309	0.343	0.455
<i>Back</i>								
Lean	47.34 ± 1.99	47.76 ± 0.98	47.33 ± 1.38	47.78 ± 2.15	47.55 ± 2.20	0.860	0.988	0.674
Bone	28.56 ± 1.30	22.72 ± 1.15	27.91 ± 1.54 ^b	26.75 ± 1.46 ^b	22.27 ± 1.79 ^a	0.001	0.019	0.887
Fat	14.40 ± 1.19	22.28 ± 1.47	16.28 ± 1.52	17.96 ± 1.77	20.78 ± 2.48	< 0.001	0.143	0.294
Remainder	9.69 ± 2.12	7.24 ± 0.67	8.48 ± 0.82	7.52 ± 0.50	9.40 ± 3.28	0.278	0.787	0.174
<i>Loin</i>								
Lean	58.83 ± 1.34	57.04 ± 1.21	58.27 ± 1.41	57.17 ± 1.13	58.37 ± 2.09	0.355	0.850	0.980
Bone	16.07 ± 0.74	14.32 ± 0.80	16.46 ± 0.72 ^b	16.80 ± 0.69 ^b	12.34 ± 0.91 ^a	0.037	< 0.001	0.042
Fat	17.67 ± 1.54	21.47 ± 1.46	17.54 ± 1.37	18.19 ± 1.44	22.98 ± 2.43	0.073	0.074	0.521
Remainder	7.43 ± 0.37	7.17 ± 0.5	7.74 ± 0.64	7.84 ± 0.30	6.31 ± 0.60	0.688	0.107	0.620
<i>Neck</i>								
Lean	57.07 ± 0.95	52.90 ± 1.76	56.83 ± 1.57	56.18 ± 1.34	51.95 ± 2.21	0.027	0.071	0.062
Bone	27.73 ± 0.94	23.45 ± 1.26	27.98 ± 1.22	24.76 ± 0.94	24.04 ± 1.95	0.008	0.092	0.449
Fat	3.65 ± 0.59	11.62 ± 2.17	4.63 ± 1.12	7.69 ± 1.15	10.59 ± 3.45	0.001	0.075	0.077
Remainder	11.54 ± 0.70	12.03 ± 1.68	10.56 ± 1.27	11.37 ± 0.57	13.43 ± 2.31	0.796	0.440	0.670
<i>Breast+Flank</i>								
Lean	53.21 ± 1.86	47.49 ± 1.95	53.22 ± 2.68	50.58 ± 2.35	47.24 ± 2.19	0.044	0.216	0.924
Bone	15.61 ± 0.45	14.67 ± 0.50	15.70 ± 0.46	15.22 ± 0.65	14.50 ± 0.64	0.171	0.343	0.298
Fat	20.63 ± 2.08	27.56 ± 2.23	20.20 ± 1.81	23.52 ± 2.51	28.57 ± 3.47	0.025	0.080	0.551
Remainder	10.55 ± 0.75	10.27 ± 1.56	10.87 ± 2.17	10.67 ± 1.07	9.70 ± 1.00	0.877	0.850	0.659

AKK: Akkaraman, BA B₁: The backcrossing of the BA (Bafra×AKK) F1 dams to the Bafra sire line, SE: Standard error, SW: Slaughter weight, G: genotype, SW×G: two-way interaction of genotype and SW, a, b: means with unlike letters in rows differ significantly (P < 0.05).

than those of the lambs slaughtered at 35 kg SW (252.49 g and 4.03) while all slaughtered weight groups (35, 45 and 45 kg) showed similar daily concentrate feed intake. One of the reasons for the lower fattening performance of the lambs slaughtered at 35 kg, can be the stress caused by the weaning and different environment (Simeonov et al., 2015). A similar result was observed for the average daily gain of the Karayaka lambs slaughtered at 35 kg SW (203.10 g) and 40 kg SW (214.50 g)

(Balci and Karakas, 2007). Another reason for this result can be from the stage of lamb development age because Abdullah et al. (2010) reported that the average daily weight gain of the lambs between 0 and 80 days (162 g/day) was lower than the lambs between 81 and 185 days (309 g/day). When the ratio of lamb testicles is evaluated, it is understood that the lambs in the 35 kg SW are in the early stage of maturing. Because the lambs in the 40 and 45 kg SW groups had higher ratios of

Table 6

Means ($\pm$ SE) for the bone percentages in the loin cut according to the genotype and SW groups.

Items	35 kg	40 kg	45 kg	P Value
AKK	17.35 $\pm$ 1.23	16.36 $\pm$ 1.33	14.50 $\pm$ 1.19	0.292
BA B ₁	15.57 $\pm$ 0.67 ^b	17.23 $\pm$ 0.48 ^b	10.18 $\pm$ 0.61 ^a	< 0.001
P Value	0.230	0.550	0.009	

AKK: Akkaraman, BA B₁: The backcrossing of the BA (Bafra $\times$ AKK) F₁ dams to the Bafra sire line, SE: Standard error, SW: Slaughter weight.

testicles (0.56 % and 0.55 %) than the lambs in the 35 kg SW group (0.43 %).

4.2. Slaughter characteristics

There was no significant difference between the genotype in hot and chilled dressing percentages based on SW, but significant differences between genotypes were observed in hot and chilled dressing percentages based on empty body weight ($P = 0.003$ and $P = 0.021$). These results were due to the genotype effect, and this type of difference among the different genotypes were reported other many studies (Abdullah et al., 2010; Al Khewani et al., 2014; Ekiz et al., 2009; Khaldari et al., 2007). These differences were caused by gut fill because while the slaughter body weights were similar, empty body weights were slightly different between the genotype ($P = 0.059$). The variations among the SW groups in both hot and chilled dressing percentages were insignificant ($P > 0.05$). These results are in agreement with the findings given by Yousefi et al., (2019), Balci and Karakas, (2007), and Unal et al., (2006).

The head percentage of BA B₁ lambs was higher than those of AKK lambs. This result was attributed to the horns of BA B₁ genotypes owing to the fact that male BA B₁ genotypes have horns. Feet and empty intestine percentages of AKK lambs were higher than those of BA B₁ lambs. AKK is a steppe climate breed, therefore these results may have originated from this. At the same time, the effect of genotype on the empty digestive tract was reported by Al Khewani et al. (2014). Bafra rams (thin and long tailed breed) and AKK ewes (fat tailed breed) crossbreeding had effects on the deposition site of fat because BA B₁ lambs had higher omental, mesenteric, and peripheric-pelvic fat, but lower tail fat percentage compared to AKK. In addition, it is reported that the breed of the dam affects peripheric-pelvic fat (Stanford et al., 1998). Testicles, liver, lung, and heart percentages were significantly different between the genotypes in this study. These types of variations between different genotypes are reported by Al Khewani et al. (2014) for testicles, Khaldari et al. (2007) for lungs, Almeida et al. (2013) for heart, and Abdullah et al. (2010), and Kashan et al. (2005) for testicles and liver.

The percentages of skin, lung, testicles, omental and mesenteric fat showed an increasing pattern as SW increased. These results are in agreement with Aksoy (1995), Aksoy and Ulutaş (2015), and Santos-Silva et al. (2002). The percentages of head and feet are lower in the 45 kg SW group than those of the 35 and 40 kg SW groups. Boujenane (2015) reported that sub-products (skin, feet, and head) percentages of carcasses showed significantly a decreasing pattern as the stage of maturity increased, and this is in agreement with current study findings. Back fat deep noticeably increased with increasing SW even though there were no significant differences, this finding was in agreement with previous studies (Díaz et al., 2002; Yakan and Ünal, 2010b; Yousefi et al., 2019).

4.3. Carcass measurements and indices

Carcass and back length of BA B₁ lambs have been significantly ($P = 0.006$ and $P < 0.001$) longer than those of AKK lambs. Dairy and prolific breeds have a long body length for genital organs (uterus and mammary glands) (Akçapınar, 2000). Bafra genotype is a prolific breed and the

milk yield of Bafra ewes is higher than those of AKK ewes. Therefore, these two traits may be high in the BA B₁ lambs because the BA B₁ genotype consists of 75 % Bafra genotype. Chest width of BA B₁ lambs has been significantly ($P = 0.030$) higher than AKK lambs, and this result is consistent with the results of the lungs weights because lung weights of BA B₁ lambs have been significantly ($P = 0.022$) higher than those of AKK lambs. On the other hand, these differences between the BA B₁ and AKK may have been caused by heterosis because Zonabend König et al. (2017) studied Red Maasai, Dorper, and Dorper $\times$ Red Maasai crosses reported heterosis effect on the body length and heart girth. AKK lambs exhibited good carcass and leg compactness index than BA B₁ lambs. This finding is in line with the lean percentage of the leg. The lean ratios of legs in the AKK lambs were significantly ($P = 0.023$) higher than those of BA B₁ lambs.

It is expected that carcass measurements increase linearly with increasing lamb weight due to the animals' growth. In this current study, all carcass measurements tend to increase with SW, although some of them are significant and some of them are considered to be insignificant. (Table 3). In principle, carcass and leg compactness indices show good accordance with SW ($P < 0.001$, Table 3), and these traits increased linearly with SW in agreement with this knowledge. Data referring to carcass measurements and compactness indices according to the SW were compatible with many previous studies (Oliveira et al., 2018; Santos et al., 2007; Yakan and Ünal, 2010b; Zgur, 2003).

4.4. Carcass cuts and composition

Percentages of individual cuts in the carcass between the genotype have been significantly different, except for the leg and foreleg. There were different reports on the comparison of pure and/or crossbred genotypes according to the carcass cuts depending on the used sheep breed. De Rezende et al. (2020) found that rib, loin, shoulder, and leg percentages in the carcass did not differ significantly among the Dorper crossbreeds slaughtered on 120 days (crossing with Morada Nova, Santa Ines, and Rabo Largo). Unal et al. (2006) reported the leg, foreleg, and back percentages in the carcass did not differ among the five genotypes, but they found different loin percentages in the carcass among these genotypes. Abdullah et al. (2010) reported loin and leg percentages were not affected by genotype but shoulders and racks were affected (Awassi, Charollais $\times$ Awassi, and Romanow $\times$ Awassi F₁ and B₁). It is understood that the percentages of the carcass cuts are different depending on the genotypes. It can be said that the neck percentage of AKK was significantly lower than those of BA B₁ lambs, due to the fact that the head percentage of AKK lambs were significantly lower than those of BA B₁ lambs. A similar result was observed between the neck percentage and weight of the head in Dhamari, Tehami, and F₁ (Dhamari $\times$ Tehami) lambs by Al Khewani et al. (2014). In addition, a higher neck and breast + flank percentage in BA B₁ lambs' carcasses caused a significantly higher third quality cuts percentage in BA B₁ lambs.

The back and loin percentages of BA B₁ carcasses were significantly higher than those of AKK lambs, this caused the difference in the percentage of first quality cuts between the genotypes and BA B₁ lambs had a higher first quality cuts percentage than those of AKK. However, this difference was not statistically significant because the leg percentage of BA B₁ carcasses had lower than those of AKK lambs. Higher lean and lower bone percentages in the carcasses are desired traits for the commercial value of the carcass. BA B₁ lambs have higher lean and lower bone percentages, and this caused a better lean/bone ratio in the BA B₁ lambs although there were no significant difference. These results are in agreement with the ribeye area measures, inasmuch as the measures ribeye areas of the BA B₁ lambs had wider than those of AKK lambs.

BA B₁ lambs showed a significantly higher fat composition and perinephric-pelvic fat percentage in the carcass and lower tail percentage and lean/fat ratio in the carcass compared to the AKK lambs. In addition, omental and mesenteric fat percentages of BA B₁ lambs were significantly higher than those of AKK lambs. Generally, fat tailed breeds

tend to deposit more fat in the tail regions than those of other regions compared to thin tailed. (de Rezende et al., 2020; Khaldari et al., 2007; Unal et al., 2006). As a result, in principle, these findings were expected because BA B₁ consists of ¼ AKK a fat-tailed breed, and ¾ Bafra a thin and long-tailed breed.

The first quality cuts percentage in the carcass of the 45 kg SW was the lowest in the SW groups due to the fact that the leg percentage in the carcass was the lowest in this SW group. This finding is consistent with Yakan and Ünal (2010b) and Díaz et al. (2002) results because Yakan and Ünal (2010b) reported the highest leg and first quality cuts ratio is identified at the 30 kg SW in the 30, 35, 40, and 45 SW groups and Díaz et al. (2002) reported the highest leg and first quality cuts ratio is identified at low SW. Yakan and Ünal (2010b) also find the highest ribeye area at the 45 kg SW, and a similar result for the ribeye area is also reported by Yousefi et al. (2019) and Al Khewani et al. (2014). These results were in agreement with this current study because the highest ribeye area was in the 45 kg SW group in this study. De Rezende et al., (2020) compared two slaughter ages (120st day and 240st day) in the 6 different genotypes and their result identified the individual cuts percentages in the carcass (rib, loin, shoulder, and leg) of the genotypes at different times shows differences according to the genotype. The individual cuts' percentages among the SW groups were not significantly different in this study, except for leg ratios.

Even though only the changing of bone percentage in the carcass was found significant ($P = 0.003$), the changing of the carcass lean, bone, and fat composition as the SW increased was suitable for the lamb growth pattern because lean and fat composition in the carcasses increased, but bone ratio decreased with the SW (Table 4). In addition, it was stated that the fat percentage increases faster at later ages (Camacho et al., 2015). Depending on these results, the lower lean/fat and higher lean/bone ratios were in the higher SW groups, and these findings are in line with many studies' results (Abdullah and Qudsieh, 2008; Camacho et al., 2015; Díaz et al., 2003, 2002; Žgur, 2003).

4.5. Composition of carcass cuts

The lean percentages in the leg and foreleg cuts, the bone percentages in the back and neck cuts, and the fat percentages in the breast+flank cuts were determined the highest in the carcass cuts. This finding was in agreement with Díaz et al. (2006), Unal et al. (2006), and Yakan and Ünal (2010b). The percentages of remainders in the carcass cuts were similar between genotypes, except for back cuts. However, the lean and bone percentage of AKK carcass cuts were higher than those of BA B₁ carcass cuts, except for AKK bone percentage of the foreleg and AKK lean percentage of the back. In addition, the fat percentages of BA B₁ carcass cuts were higher than those of AKK carcass cuts. This is an expected result because it is well known that the thin-tailed breed tends to deposit more fat in the body than those of the fat-tailed breed. The bone percentage decreased, and the fat percentage increased as SW increased in all carcass cuts. The fat percentages of leg cuts, the lean percentages of back cuts, and the bone percentages of loin cuts were partially similar to the fat, lean, and bone percentages of the carcasses, respectively.

5. Conclusion

Genotype usually affected the fattening, slaughter, and carcass traits even though some traits for example heart, trachea+esophagus, kidneys, and foreleg percentages between the genotypes were evidently similar. When the fattening, slaughter, and carcass traits are evaluated together, it is understood that BA B₁ lambs have better fattening and carcass performance than those of AKK lambs although AKK lambs have better hot and chilled dressing percentages compared to BA B₁ lambs. Carcasses from the high SW groups had lower bone and higher fat percentages, and carcasses from the low SW groups had the higher first quality carcass section; on the other hand, lean/bone and lean/fat ratios were not different among the SW groups. Based on this study, it can be

recommended that slaughtering in the 40 or 45 kg SW is appropriate from the perspective of fattening performance, slaughter characteristics, carcass measurements, and carcass compositions for AKK and BA B₁ lambs.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Ethical standards

All animal procedures were conducted under the protocol approved by the Ankara University Animal Experiments Local Ethics Committee (File no. 2018-34, Decision no. 2018-4-36).

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