Effect of breed and fattening system on fattening performance, rumen and blood parameters in Akkaraman, Karayaka and Herik lambs under indoor conditions

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ABSTRACT

This research was performed to determine comparative effect of concentrate and forage-based diets on fattening performance, rumen and blood serum parameters of Akkaraman, Karayaka and Herik lambs under intensive indoor conditions. In this study forty-five single male lambs, aged 2.5-3 months, were randomly selected from the same flock of each breed. The lambs were divided into two different concentrate/forage ratios (70/30 and 30/70) for each breed. The lambs were fed with concentrated feed and dry alfalfa until they reached 40 kg slaughter weight. In both of diet groups, average daily weight gain (ADWG) and feed conversion rate (FCR) for Akkaraman lambs were better than those of Karayaka and Herik lambs. The rumen pH of the concentrate groups was significantly lower than that of the forage groups for all breeds ($P < 0.001$). Total volatile fatty acid (TVFA) for Herik lambs was higher than that of Akkaraman and Karayaka lambs in both of diet groups. TVFA and total ammonia nitrogen (NH_3-N) concentrations of lambs in the concentrate groups were significantly higher than those of the lambs in the forage groups ($P < 0.001$). Consequently, the study indicates that fattening performance for Akkaraman lambs was better than that of Karayaka and Herik lambs in both of diet groups, as shown by higher ADWG and better FCR values. The diet was effective ($P < 0.001$) on all rumen parameters. Also, the present study confirms that blood parameters have normal levels.

Introduction

Sheep breeding in Türkiye is mainly performed by traditional farms. Approximately 80-90% of these farms source their animals' feed requirements from pastures. However, the gradual reduction in natural pasture areas and excessive and uncontrolled grazing have led to a deterioration in the quality of existing pastures. This has resulted in natural pastures being unable to provide the nutritional requirements of lambs for fattening (14). Therefore, there has been a shift in lamb meat production in recent years, with an increasing number of sheep farms feeding lambs a concentrate-based diet until they reach slaughter weight after weaning in intensive breeding conditions (4, 8, 28). Hence, previous studies have focused on investigating the effects of concentrate-based diets (4, 6, 24) or the supplementation of concentrated feed, in addition to pasture grazing, on the fattening performance of lambs (21, 24**)** and ruminal fermentation (4, 16) and blood serum parameters (5, 23).

Yavuz et al. (2020) (33) reported that while the share of forage crops in field agriculture was 1.6% in the early 2000s, it increased to 8.2% in 2010 and 13% in 2019.

Therefore, Turkiye has recently seen an increase in the potential for forage crops production. This suggests that it may be possible to create a sustainable farming model for lamb meat production by feeding lambs with a forage-based diet after weaning indoors. However, limited information is available regarding a comparative effect of concentrate and forage-based diets on fattening performance, rumen and blood serum parameters.

Numerous native sheep breeds are raised in Turkey. These breeds are primarily reared for meat production. The three most common native sheep breeds in Turkey are the Akkaraman (45%), Herik, and Karayaka (6%), which together constitute approximately 50% of the sheep population in the country (13). Akkaraman lambs, raised in the Central Anatolia Region, are generally used for lamb meat production. Karayaka lambs, are another native breeds of Turkey, raised for lamb meat production in the Black Sea Region. Herik sheep is one of the local sheep breeds raised in the border area between Central Anatolia and the Black Sea Region in Turkey. Herik sheep is thought to have resulted from the irregular crossbreeding of the Akkaraman with the Karayaka (1).

We hypothesized that the use of concentrate/forage in the diet would have different effects on fattening performance, rumen and blood serum parameters in different breeds. The present study aims to compare the effect of concentrate and forage-based diets on fattening performance, rumen and blood serum parameters of Akkaraman, Karayaka and Herik lambs under intensive indoor conditions.

Materials and Methods

Animals, Experimental Design, Housing and Nutritional Conditions: The study was conducted at the Agricultural Faculty Research and Application Farm of the Ondokuz Mayıs University. The farm is located at 41° N and 36° E at an altitude of 223 m above sea level. A total of 45 male lambs (Akkaraman (n=14), Karayaka (n=15) and Herik (n=16)), aged 2.5-3 months, were selected with simple random sampling from the same flock of each breed. The concentrated feed amount for lamb diets generally were reported to be 70% or more under intensive production systems (4, 8, 23, 27). Thus, diets were arranged into groups of two different concentrate/forage ratios (70/30 and 30/70) to determine a comparative effect of concentrate and forage-based diets. The stocking density at the stockyard was 0.7 m^2. The crib length was 30 cm per lamb. All lambs were vaccinated against clostridial disease. They were treated with anthelmintics for parasitic disease.

The nutrient contents of concentrate and forage used on lambs during fattening are presented in Table 1. The slaughter weight at which native sheep breeds exhibit the most efficient fattening performance generally varies between 35 and 40 kg, depending on market conditions in Türkiye (3, 25, 27). The lambs were fed a diet consisting of a concentrate and alfalfa hay *ad libitum* in specified ratios to meet or exceed nutritional requirements recommended by National Research Council (NRC) (2007) (20) until they reached a slaughter weight of 40 kg. The animals had free access to clean water and salt licks. Before the fattening period, the lambs were adapted to the high-concentrate diets using a 15-day step-up protocol. The concentrate and forage were applied as a mixed ration. Leftover feed (concentrate and forage) for each group were collected and weighed daily to calculate the daily total feed intake (DTFI). Lambs were weighed with a digital scale (UWE trademark) sensitive to 100 g individually on a weekly basis after a 16-hour fasting period, and the ADWG and FCR of each group were calculated (27).

Table 1. Nutrient contents of concentrate and roughage used to lambs during fattening.

Nutrient content	Concentrate	Alfalfa
Dry matter (%)	89.74	90.19
Crude protein (%)	16.05	17.25
Ether extraction (%)	3.77	2.09
Ash (%)	7.20	10.11
aNeutral Detergent Fiber (%)	22.93	38.89
Acid Detergent Fiber (%)	12.12	29.23
Metabolic Energy (kcal / kg)	2844.00	2031.54

Chemical Analysis: Samples of dietary ingredients (concentrate and alfalfa hay) were ground and passed through a 1-mm sieve to analyze the following contents according to the AOAC (1995) methods (2) for dry matter, ash, crude protein and ether extract. The neutral detergent fiber (NDF) content was determined as described by Mertens (2002) (19), using heat-stable alpha-amylase (CAS number:9000-90-2, ANKOM technology, USA) and sodium sulfite (CASNumber:7757-83-7, Sigma Aldrich, Germany). The acid detergent fiber (ADF) content was determined according to the method of Van Soest (1991) (28). The analysis of both NDF and ADF was performed using the fiber analyzer (ANKOM 200, ANKOM Technolgy, USA). The metabolic energy was calculated for the concentrate (26) and alfalfa hay (15).

Rumen Fluid Analysis: Rumen fluids (per animal 100 ml) were collected from lambs that had reached the slaughter weight of 40 kg using a rumen probe within 2-4 hours after the morning feeding. Immediately after collection, rumen pH was measured using a pH meter device (Mettler Toledo S220-K Seven Compact). The rumen fluids were then filtered through a four-layer gauze and divided into two sub-samples of 10 ml each for the analysis of TVFA

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and NH_3-N that were determined according to the steam distillation method of Markham (1942) (18).

Blood Sample Analysis: Blood samples were obtained from the jugular vein of lambs that had reached the slaughter weight of 40 kg using 10 ml vacuum tubes within 2-4 hours after the morning feeding. The samples were promptly transported to the laboratory on the same day. Subsequently, the samples were centrifuged at 3000 rpm for 10 minutes (NF 400, Nüve), and their serum was extracted. Glucose, cholesterol, triglyceride, and total protein levels in the blood serum were measured using an autoanalyzer device (RX Monaco; Randox Laboratories Ltd). The analyses were conducted using Randox RX series commercial kits for glucose (Randox RX series, lot no:566742), cholesterol (Randox RX series, lot no:586186), triglyceride (Randox RX series, lot no:603655), total protein (Randox RX series, lot no:597288) and control serum (Randox control, lot no:1586UN).

Statistical Analysis: Descriptive statistics of live weight, average daily weight gain and feed conversion ratio were determined for fattening performance because of group feeding was performed in this study. The homogeneity of variances were evaluated with the Levene Test. General Linear Model (GLM) was performed for the comparision of rumen and blood parameters in breed, diet and breed × diet and determination of the significance of differences between the groups was done with the Duncan test. Statistical analyzes were done using the SPSS packed programs (IBM Inc., USA, version 21) (9). A level of $P<0.05$ was accepted as statistically significant.

The statistical model assumed for the evaluation of breed and diet on ADWG, rumen and blood serum parameters was as fallows;

$Yijk=\mu + Bi+Dj+eijk$

Yijk= traits of any lamb (i. breed, j.diet)

μ =overall mean, B_i=effect of i^{th}breed of lamb (i: Akkaraman, Karayaka and Herik), D_j= effect of j^{th} diet (j: based on concentrate, based on forage), eijk=Random error.

Results

***Fattening Performance*:** The fattening performance was evaluated based on ADWG and FCR. The results for ADWG and FCR in all groups were presented in Table 2, Table 3, and Table 4 respectively. The ADWG exhibited a fluctuating pattern during the fattening period in all groups. Generally, it tended to increase from the initial day until the 35^{th} day in all groups, followed by a decreasing trend until the end of the fattening period. The ADWG and FCR for days between 15-21 and 29-35 were better than those of other periods. Notably, Karayaka lambs in the forage group showed a significant decrease in ADWG from the 84^{th} day until the end of fattening. In this study, the lambs were slaughtered when they reached an average weight of 40 kg. The fattening period of Akkaraman (70 days) was lower than that of Karayaka (91 days) and Herik (91 days) in concentrate diet groups. The corresponding values for Akkaraman, Karayaka, and Herik in forage diet groups were determined as 97, 146, and 118 days, respectively. Also, ADWG and FCR of Akkaraman was higher than those of Karayaka and Herik in both of diet groups (Table 5).

Table 2. The means of initial weight (IW), live weight (LW), average daily weight gain (ADWG), feed convertion ratio (FCR) for the Akkaraman lambs.

Akkaraman-Concentrate					Akkaraman-Forage				
Days	n	LW (kg)	ADWG (g)	FCR	Days	n	LW (kg)	ADWG (g)	FCR
IW	7	24.26±1.06	-	-	IW	7	23.80±0.93	-	-
0.-7.	7	26.09±1.05	261±0.02	6.07	0.-7.	7	24.85±0.89	150±0.01	8.28
8-14.	7	28.23±1.10	305±0.01	5.66	8-14.	7	25.94±0.85	156±0.03	8.92
15-21.	7	30.30±1.23	297±0.04	6.29	15-21.	7	27.76±1.01	259±0.02	5.72
22-28.	7	31.98±1.22	240±0.02	8.17	22-28.	7	29.37±1.01	230±0.03	7.19
29-35.	7	34.29±1.29	330±0.02	5.09	29-35.	7	30.99±1.09	231±0.02	6.72
36-42.	6	35.41±1.19	231±0.04	8.53	36-42.	6	32.51±1.13	218±0.01	8.28
43-49.	6	36.85±1.04	204±0.03	8.43	43-49.	6	33.90±1.02	198±0.02	8.92
50-56.	6	38.28±0.98	204±0.03	8.46	50-56.	6	34.84±1.04	134±0.01	12.53
57-63.	5	39.36±0.70	254±0.04	9.05	57-63.	6	36.24±0.96	199±0.01	9.23
64-70.	3	39.73±0.23	214±0.05	11.01	64-70.	6	37.78±1.05	220±0.02	8.87
0.-70.		-	270±0.01	6.83	71-77.	4	37.47±1.11	207±0.01	10.64
					78-84.	2	37.05±0.25	207±0.05	11.00
					85-91.	2	38.40±0.10	193±0.01	10.47
					91-97.	2	39.70±0.10	186±0.01	9.17
					0.-97.		-	201±0.01	9.00

Table 3. The means of initial weight (IW), live weight (LW), average daily weight gain (ADWG), feed convertion ratio (FCR) for the Karayaka lambs.

Karayaka-Concentrate					Karayaka-Forage				
Days	n	LW (kg)	ADWG (g)	FCR	Days	n	LW (kg)	ADWG (g)	FCR
IW	8	23.69±0.66	-	-	IW	7	21.01±0.78	-	-
0-7.	8	25.68±0.71	284±0.01	4.84	0-7.	7	21.99±0.75	139±0.01	8.02
8-14.	8	27.45±0.81	252±0.01	5.56	8-14.	7	23.15±0.84	166±0.01	6.95
15-21.	8	29.57±0.96	302±0.03	4.68	15-21.	7	24.53±0.86	196±0.01	6.36
22-28.	8	31.25±0.97	241±0.01	6.05	22-28.	7	25.67±0.85	162±0.01	8.14
29-35.	8	32.98±0.95	247±0.01	5.45	29-35.	7	27.09±0.97	202±0.02	5.95
36-42.	8	34.11±1.09	162±0.02	9.53	36-42.	7	28.07±0.94	141±0.01	5.53
43-49.	8	35.13±1.04	146±0.02	9.00	43-49.	7	29.17±1.00	157±0.01	8.59
50-56.	8	36.53±1.09	200±0.02	6.44	50-56.	7	29.97±1.04	114±0.01	11.74
57-63.	7	37.22±1.02	179±0.01	6.80	57-63.	7	31.32±1.05	193±0.02	7.45
64-70.	5	37.14±0.66	174±0.03	9.40	64-70.	7	32.37±1.19	150±0.02	9.42
71-77.	4	38.40±0.66	253±0.01	6.35	71-77.	7	33.82±1.20	207±0.02	6.85
78-84.	2	38.70±0.10	207±0.01	4.69	78-84.	6	34.18±1.16	163±0.03	9.79
85-91.	2	40.40±0.10	243±0.01	2.73	85-91.	6	34.95±1.16	110±0.01	11.00
0-91.		-	212±0.01	6.27	91-97.	6	35.75±1.05	114±0.02	11.92
					98-104.	6	37.46±0.54	107±0.01	13.06
					105-111.	6	38.18±0.56	102±0.01	14.56
					112-118.	6	38.93±0.57	107±0.01	15.12
					119-125.	4	38.70±0.29	92±0.01	21.61
					126-132.	3	39.23±0.38	100±0.01	20.14
					133-139.	3	39.90±0.45	95±0.01	21.15
					0-139.		-	151±0.01	11.86

Table 4. The means of initial weight (IW), live weight (LW), average daily weight gain (ADWG), feed convertion ratio (FCR) for the Herik lambs.

Herik-Concentrate					Herik-Forage				
Days	n	LW (kg)	ADWG	FCR	Days	n	LW(kg)	ADWG	FCR
IW	8	23.98±0.91	-	-	IW	8	22.80±0.77	-	-
0-7.	8	26.23±0.97	321±0.02	4.43	0-7.	8	23,63±0.83	118±0.02	10.06
8-14.	8	27.79±1.09	223±0.02	6.75	8-14.	8	24.46±0.90	119±0.02	10.34
15-21.	8	29.92±1.16	305±0.03	5.17	15-21.	8	26.18±0.90	245±0.01	5.35
22-28.	8	31.46±1.27	221±0.02	7.63	22-28.	8	27.30±0.90	160±0.01	9.14
29-35.	8	33.57±1.31	301±0.02	4.97	29-35.	8	28.63±0.99	190±0.02	7.42
36-42.	8	35.37±1.32	266±0.01	7.34	36-42.	8	29.78±0.98	164±0.01	9.76
43-49.	6	35.31±1.18	202±0.01	9.25	43-49.	8	31.00±1.17	173±0.03	9.42
50-56.	6	36.65±1.14	190±0.03	9.37	50-56.	8	31.98±1.18	142±0.01	11.61
57-63.	5	37.08±1.08	174±0.04	11.08	57-63.	8	33.60±1.32	230±0.03	7.56
64-70.	4	37.90±0.91	246±0.02	7.21	64-70.	7	33.51±0.77	153±0.01	11.44
71-77.	3	38.53±1.28	176±0.06	10.90	71-77.	7	35.05±0.88	220±0.03	7.88
78-84.	2	38.75±0.25	214±0.02	7.61	78-84.	7	36.08±0.79	147±0.01	11.85
85-91.	2	40.25±0.45	214±0.02	7.24	85-91.	7	37.27±0.88	169±0.02	10.10
0-91.		-	255±0.04	7.61	91-97.	5	37.22±0.53	174±0.01	10.49
					98-104.	5	38.12±0.43	128±0.01	13.59
					105-111.	5	39.06±0.35	134±0.01	12.96
					112-118.	3	39.86±0.21	181±0.01	11.23
					0-118.		-	173±0.01	10.01

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Table 5. Fattening performance traits of lambs at the end of the fattening period (kg).

	Concentrate						Forage						P		
Items	n	Akkaraman	n	Karayaka	n	Herik	n	Akkaraman	n	Karayaka	n	Herik	B	D	B×D
IW	7	24.26±1.06	8	23.69±0.66	8	23.98±0.91	7	23.80±0.93	7	21.01±0.78	8	22.80±0.77	-	-	-
SW	7	40.44±0.27	8	40.08±0.25	8	40.27±0.25	7	39.80±0.27	7	40.20±0.27	8	40.21±0.25	-	-	-
ADWG	7	0.270±0.01	8	0.212±0.01	8	0.255±0.04	7	0.201±0.01	7	151±0.01	8	0.173±0.01	*	***	-

-: non significant, *: P<0.05, ***: P<0.001 Different superscripts indicate significant differences in the same line.
B: breed; D: diet; B × D: breed and diet interaction

Table 6. Rumen parameters of lambs at the end of the fattening period.

	Concentrate						Forage						P		
Items	N	Akkaraman	n	Karayaka	n	Herik	n	Akkaraman	n	Karayaka	n	Herik	B	D	B×D
Rumen pH	7	5.79±0.89	8	5.50±0.83	8	5.50±0.83	7	6.12±0.89	7	6.27±0.83	8	6.32±0.83	-	***	*
Total VFA (mmol/L)	7	88.67±6.29	8	85.55±5.88	8	103.01±5.88	7	64.23±6.29	7	69.18±5.88	8	78.09±5.88	*	***	-
Total NH_3 (mg/dl)	7	23.94±1.81	8	24.98±1.69	8	25.49±1.69	7	16.65±1.81	7	18.54±1.69	8	21.15±1.69	-	***	-

-: non significant, *: P<0.05, ***: P<0.001 Different superscripts indicate significant differences in the same line.
B: breed; D: diet; B × D: breed and diet interaction.

Table 7. Blood metabolites of lambs at the end of the fattening period.

	Concentrate						Forage						P		
Items	n	Akkaraman	n	Karayaka	n	Herik	n	Akkaraman	n	Karayaka	n	Herik	B	D	B×D
Glucose (mg/dl)	7	68.08±3.14	8	62.10±2.94	8	64.29±2.94	7	63.17±3.14	7	65.12±3.14	8	82.30±2.94	-	-	-
Cholesterol (mg/dl)	7	72.87±5.86	8	70.57±5.48	8	79.48±5.48	7	57.34±5.86	7	68.20±5.86	8	77.65±5.48	-	-	-
Trigliserit mg/dl	7	22.34±2.64	8	17.77±2.47	8	24.46±2.47	7	20.13±2.64	7	21.87±2.64	8	23.95±2.47	-	-	-
Total protein(g/dl)	7	6.75±0.26	8	6.16±0.24	8	6.41±0.24	7	6.44±0.26	7	6.63±0.26	8	6.66±0.24	-	-	-

-: non significant, B: breed; D: diet; B × D: breed and diet interaction

Rumen Fluid Analysis: The rumen pH, TVFA and NH_3-N concentrations within the rumen fluid were presented in Table 6. The rumen pH of Akkaraman (5.70), Karayaka (5.50), and Herik (5.50) lambs in the concentrate groups was lower than the corresponding values (6.12, 6.27, 6.32) for the forage groups (P<0.001). The rumen pH was also significantly affected by the genotype × feeding interaction (P<0.05), but there was no significant difference between the genotype groups.

TVFA and NH_3-N concentrations of lambs in the concentrate groups were significantly higher than those of the forage groups (P<0.001). Additionally, in all groups, the TVFA and NH_3 concentrations of Herik lambs were significantly higher than those of Akkaraman and Karayaka lambs (P<0.05).

Blood Sample Analysis: The serum glucose, cholesterol, triglyceride and total protein concentrations were presented in Table 7. There was no significant difference in serum glucose, cholesterol, triglyceride and total protein concentrations among the breeds (Akkaraman, Karayaka, and Herik) in all feeding groups (P>0.05). However, serum cholesterol and triglyceride concentrations of Herik lambs were higher than those of Akkaraman and Karayaka lambs in all feeding groups (P<0.05). Serum glucose concentrations of Akkaraman lambs were higher than those of Karayaka and Herik lambs in the concentrate groups while serum glucose and total protein concentrations of Herik lambs were higher than those of Akkaraman and Karayaka lambs in the roughage groups.

Discussion and Conclusion

Fattening Performance: Fattening performance is commonly assessed using metrics ADWG and FCR. The slaughter weight at which native sheep breeds exhibit the most efficient fattening performance generally varies between 35 and 40 kg, depending on market conditions in Türkiye (3, 25, 27). In this study, the lambs were slaughtered when they reached an average weight of 40 kg.

In this study, although the ADWG exhibited a fluctuating pattern during the fattening period in all groups, it tended to increase from the initial day until the 35th day in all groups Especially, ADWG and FCR for days between 15-21 and 29-35 were better than those of

other periods. These differences can be explained by the effects of climatic conditions. Indeed, periods between 15-21 and 29-35 days were before the soltice on June 21, followed by a decreasing trend until the end of the fattening period with ambient temperature increased after the soltice.

In present study, ADWG and FCR of Akkaraman was better than that of Karayaka and Herik lambs in both of diet groups. Also, Akkaraman lambs were found to have a shorter fattening period than Karayaka and Herik lambs in both of diet groups. In a study, Yıldırım et al. (2014) (34), reported that the intestinal lengths of Akkaraman lambs were longer than those of Karayaka lambs. This suggests that Akkaraman lambs may be able to better utilize feed material that remains in the digestive system for a longer period of time. Also, ADWG and FCR of Karayaka exhibited dramatic decline after live weight of 35 kg in forage group. It can be explained that adult body weight of the Karayaka lambs. It may be related to adult body weight of the Karayaka breed that was reported to be 35-40 kg (1).

In the present study, ADWG and FCR was 270 g, 6.83 for Akkaraman, 212 g, 6.27 for Karayaka and 255 g, 7.61 for Herik lambs fed concentrate-based diets. ADWG and FCR in this study were higher than those of some studies slaughtered with a body weight of approximately 40 kg (3, 25, 27). Another study with Akkaraman lambs slaughtered at 42 kg reported the ADWG and FCR values of 283 g and 4.02, respectively (8). These results had better ADWG and FCR than those reported for Akkaraman (270 g, 6.83) in our studies. These differences can be explained by the effects of climatic conditions, rumen microbiota, as the research was conducted in different regions with different management processes.

In the present study, Akkaraman (201 g), Karayaka (151 g) and Herik (173 g) lambs fed forage had poorer ADWG than that reported for Tuj (21) and Hemşin (24) lambs under semi-intensive production systems. This disparity may be due to a combination of factors, including lamb genotype, nutritional conditions, and management practices.

Rumen Fluid: The pH, TVFA and NH_3-N are the primary indicators of ruminal fermentation. These parameters are closely associated with dietary concentrate-forage ratios (17). Readily fermentable carbohydrates, such as starch and soluble sugars found in high-concentrate diets, undergo rapid fermentation, leading to an increase in the production of volatile fatty acids (VFAs) and consequently resulting in a decline in ruminal pH (30). In our study, we similarly observed that elevating dietary concentrate level was consistently linked to decreased ruminal pH and increased TVFA concentrations, regardless of the breed. Previous studies have reported that the optimal concentrations of ruminal NH_3-N, necessary for ideal ruminal fermentation and nutrient utilization, vary between 8.5 and 30 mg/dL (12). In the present study, rumen NH_3-N levels in all experimental groups were within this range. Besides, high-concentrate feed levels elevated ruminal NH_3-N concentration, which is consistent with the former studies (22, 32). The recommended ruminal TVFA concentration range is 60–150 mmol/L (7); that within our study was 64.23–103.01 mmol/L. Meanwhile, this experiment found that the TVFA concentration of Herik lamb was significantly higher than that of Akkaraman and Karayaka in both concentrate and forage feeding regimes. This result is consistent with Wang et al. (2024)'s (31) theory that breed-specific variations in rumen fermentation patterns contribute to differences in ruminal volatile fatty acids production.

Blood Parameters: The measurement of blood serum metabolites is crucial for monitoring animals' overall health and assessing diet-induced changes in energy and protein metabolism. In our study, serum glucose (62,1–82,3 mg/dL), cholesterol (57,3–79,4 mg/dL), triglyceride (17,7–24,4 mg/dL), and total protein (6,1–6,7 g/dL) levels in all groups remained within the reference ranges for healthy lambs from birth to 1 year of age (glucose: 50–115 mg/dL, triglycerides: 10–45 mg/dL, cholesterol: 40–130 mg/dL, and total protein: 5.0–7,8 g/dL) (11, 29). Several researchers have reported that concentrate-based diets cause an increase in serum energy status indicators such as glucose, triglyceride, and cholesterol compared to forage-based diets (10, 12). However, no significant difference was observed between the feeding groups in our study. This may be because the study was terminated at the same slaughter weight, preventing excessive fattening of animals.

Consequently, the study indicates that fattening performance for Akkaraman lambs was better than that of Karayaka and Herik lambs in both of diet groups, as shown by higher ADWG and better FCR values. As for rumen parameters, TVFA for Herik lamb higher than that of Akkaraman and Karayaka lamb in both of diet groups. The diet was effective on all of rumen parameters. Growth of lamb with concentrate-based diet better than that of lamb with forage based diet due to greater ruminal fermentation. Also, the present study confirms that blood parameters have normal levels.

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Ethical Statement

This study was carried out after the animal experiment was approved by the Ondokuz Mayis University Local Ethics Committee (Decision number: HADYEK2019/54).

Conflict of Interest

The authors declared that there is no conflict of interest.

Author Contributions

MU; study conception, design, methodology, material preparation, data collection, data analysis, writing and conceptualization. AU, BN, BB, FA and DA; data collection and data analysis. İK; conceptualisation. FA and BT; methodology, material preparation, data collection, data analysis and conceptualization.

Data Availability Statement

The data supporting this study's findings are available from the corresponding author upon reasonale request.

Animal Welfare

The authors confirm that they have adhered to ARRIVE Guidlines to protct animals used for scientific purposes.

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