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Milk yield, quality, udder traits and lamb growth in Lalahan sheep, a new crossbred genotype

H.H. Şenyüz,[1*] Y. Ergiden,[2] Ç.Yıldırım,[2] Ö.O. Parıldar,[2] F.I. Coner,[2] S. Fırdolaş,[2] M.İ. Coşkun,[2] E. Odabaş,[3] F. Mızrak,[2] Y. Zengin,[2] H. Erol,[4] K. Kara,[5] N. Ünal[6]

[1]Necmettin Erbakan University, Faculty of Veterinary Medicine, Department of Animal Nutrition and Nutritional Disease, Konya, Türkiye.

[2]International Center for Livestock Research and Training, Ankara, Türkiye.

[3]General Directorate of Agricultural Research and Policies, Ankara Türkiye.

[4]General Directorate of Livestock, Ankara, Türkiye.

[5]Erciyes University, Faculty of Veterinary Medicine, Department of Animal Nutrition and Nutritional Disease, Kayseri, Türkiye.

[6]Ankara University, Faculty of Veterinary Medicine, Department of Animal Breeding and Husbandry, Ankara, Türkiye.

ABSTRACT: The Lalahan sheep is a new genotype developed to suit the steppe conditions of lamb production in Turkey. It is important to determine the milk yield and quality of this new genotype to produce high-quality lamb meat. Additionally, the ewes can also be utilized for milk production under steppe conditions. This study investigated the milk yield, milk quality, udder characteristics, and lamb growth of the Lalahan genotype. Milk yield traits were assessed based on lactation number (LN) and lactation month (LM). The lambs were divided into two groups during the suckling period: the maternal milk feeding group (M) and the maternal milk with creep feeding group (CF). The daily milk yield for ewes with LN 1, 2 and 3 was 0.406±0.02, 0.560±0.05 and 0.446±0.02 kg, respectively ($P<0.001$). Similarly, the lactation milk yield for the same groups was 61.19±3.14, 83.49±7.47 and 65.39±3.73 kg, respectively ($P<0.001$). The udder characteristics showed significant differences ($P<0.01$, $P<0.001$) with LM. Milk's chemical composition, including fat, protein, lactose, and dry matter, changed significantly ($P<0.05$, $P<0.01$, $P<0.001$) due to LN and LM. Fatty acids did not differ significantly among the LN, but they generally differed significantly according to LM ($P<0.05$, $P<0.01$, $P<0.001$). Half of the total fatty acids were composed of C16:0 + C18:1 acids, and the mean UFA ratio was 23.70±0.31% throughout lactation. The levels of PUFA, w3, and w6 gradually increased throughout lactation ($P<0.001$). Except for 180 days ($P<0.001$), there were no significant differences ($P>0.05$) in the growth performance of the lambs during the suckling period between the M and CF groups. As a result, the study revealed that the milk yield of Lalahan sheep is comparable to that of local meat-type sheep breeds. Their udder type is suitable for machine milking and milk quality is comparable in terms of fatty acids and milk constituents.

Keyword: Lalahan sheep; udder; steppe conditions; milk yield; fatty acids.

Correspondence author:
H.H. Şenyüz,
Necmettin Erbakan University, Faculty of Veterinary Medicine,
Department of Animal Nutrition and Nutritional Disease, Konya, Türkiye.
E-mail address: hasansenyuzvet@yahoo.com

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INTRODUCTION

Sheep are bred in Türkiye primarily for meat, milk and fleece. To achieve this, breeds such as Akkaraman, Kıvırcık and Central Anatolian Merino are used for meat production, while Awassi and Chios are kept for milk production. Although the meat-producing farms produce a small amount of milk, it is still used for local consumption. Male lambs from dairy farms are also used for meat production (Akçapınar, 2000; Akçapınar and Özbeyaz, 2021).

The Akkaraman breed is widespread in Central Anatolia and the most numerous in Türkiye. It has a fat tail and is well adapted to the steppe climate. The Kıvırcık breed is raised in the Marmara and Aegean regions where the Mediterranean climate prevails. It is characterised by a long and thin tail. It is considered to be the best local sheep breed in terms of meat quality (Ünal et al., 2004). Pure breeding of the Kıvırcık breed under Central Anatolian steppe conditions cannot achieve the expected performance. Therefore, the Lalahan sheep breed was developed by backcrossing and combination crosses between the Kıvırcık and Akkaraman sheep breeds in order to obtain new genotypes for lamb meat production under steppe conditions (Arslan and Ünal, 2023).

Crossbreeding studies of Lalahan sheep between Kıvırcık and Akkaraman breeds started in 1995 at Ulaş State Farm and continued at Lalahan International Centre for Livestock Research and Training (Ünal et al., 2004). Lalahan sheep have good reproductive performance and are similar to the Kıvırcık breed in morphological characteristics (Erol et al., 2017). Generally matin g season is September, and birth season February. It is seasonal in which breeding is still carried out in domesticated and native breeds (Antonopoulou et al., 2024). Arslan and Ünal (2023) reported that Lalahan lambs have similar fattening performance, slaughter, carcass and meat quality to the Kıvırcık breed, making it a suitable breed for Central Anatolia. While the Lalahan sheep has been developed primarily for lamb production, further scientific studies are needed to determine its milk production potential.

The milk yield of ewes can be influenced by various factors such as breed, age, body condition, diet, lambing season, birth type, lactation number, and lactation duration. Typically, some local and crossbred genotypes, which could be defined as meat-type sheep, produce between 70-150 litres of milk during the entire lactation period, which lasts for 3-5 months. The morphological characteristics of the ewe's udder and teats are crucial to the milking process. The size of the teat is particularly important when machine milking is used, as it should be appropriate for the milking process. In Akkaraman ewes, udder circumference, distance between teats, teat length, and teat width were reported to be 43.75-47.77 cm, 16.56-17.63 cm, 25.53-25.22 mm, and 12.98-10.01 mm respectively (Yardımcı and Özbeyaz, 2001; Mundan and Özbeyaz, 2004). The corresponding values for Kıvırcık ewes were 35.09-37.2 cm, 16.50 cm, 27.3-28.8 mm, and 18.8 mm as reported by Altınçekiç and Koyuncu (2011) and Akgün and Koyuncu (2021), respectively.

Milk and dairy products are important sources of human nutrition due to their balanced nutrient content. The nutritional value of these products is primarily related to the fat content and quality of the milk, which also influences the taste and flavour of the product (Markiewicz-Kęszycka et al., 2013).

Lamb growth is a major concern in sheep production as it has a direct impact on meat yield. Birth weight, weaning performance and fattening performance are key factors influencing yield. According to the literature, the Akkaraman breed has a birth weight range of 3.73-4.92 kg, 60-day live weight (LW) range of 12.47-19.50 kg, and 180-day LW range of 35.91-38.69 kg (Akçapınar et al., 2000). In previous studies (Yakan et al., 2012; Türkmen and Çak, 2021; Ceyhan et al., 2007; Alarslan and Aygün, 2019), the corresponding values for Kıvırıcık lambs were reported as 4.09-4.49 kg, 13.94-17.91 kg and 33.86-43.14 kg, respectively.

The aim of this study was to investigate milk yield, milk quality, udder characteristics and lamb growth in Lalahan sheep developed for steppe conditions.

MATERIAL AND METHOD

This study was conducted under the ethical approval of the International Livestock Research and Training Center Animal Experiments Local Ethics Committee (Approval number: 20.12.2019-172).

The animal material used in the study comprised 53 Lalahan ewes that had undergone single parturition during their 1st, 2nd, and 3rd lactation cycles, as well as 20 female and 20 male lambs that were available at the International Livestock Research and Training Center in Ankara, Türkiye. The study was conducted between March and August 2022. The ewes were placed in a yard in January for winter and pregnancy care. During this period, the ewes were provided with 800 g of forage, which was a combination of 50% barley straw and 50% alfalfa hay, along with 800 g of concentrate feed containing 16% CP and 2600 kcal/kg ME for six weeks before lambing. Following lambing, their diet was adjusted to 800 g of forage (a mixture of 50% barley straw and 50% alfalfa hay) and 1000 g of concentrate feed (19% CP, 2600 kcal/kg ME). The ewes were turned out to pasture in mid-April and were fed exclusively on pasture thereafter. No additional feeding was provided during this period.

Table 1 shows the composition and calculated nutrient values of the concentrate feed, while Table 2 presents the nutritional contents of the consumed feeds. The nutrient content of roughages and concentrated feeds was analysed using the AOAC (1993) method for dry matter (DM), ash, and crude protein (CP). In addition, neutral detergent fibre (NDF) and acid detergent fibre (ADF) analyses were performed according to Van Soest (1965).

To determine milk yield during lactation, 50 ewes were randomly selected according to the lactation number. The first milk control was performed in the first month after lambing. The lambs were separated from their mothers at 9:00 pm on the evening before the control day. Milking was performed at 9:00 am and 8:00 pm on the control day using a mobile milking machine. Routine machine milking management was applied before and after milking, and machine stripping was also practiced. During the control days, the lambs were fed using latex teats. Milk controls were conducted monthly until the milk yield of the ewes dropped below 100 g. On each control day, 50 ml milk samples were collected by combining morning and evening milk.

Lactation milk yields were calculated using the Trapezoid II method (Maria and Gabina, 1992) as follows.

$[(k_1 \text{ x } A) + (k_1 + k_2) / 2 * a_1 + \ldots\ldots\ldots\ldots (k_n \text{ x } A) + (k_{n-1} + k_n) / 2 * a_n + k_n \text{ x } C)]$ formula was used.

(a: Control range; n: Number of control; k: Amount of milk yield in control; A: Days between lambing date and first control date; C: Days between last control and dry period).

Table 1. The ration composition and calculated nutrient of consumed feeds DM (%).

	Barley	Corn	Soybean Meal	Sunflower Meal	Bran	Ca Carbonate	Salt+Vit-Min	DCP
Starter concentrate feed	42.6	18	16	6	12	2	0.9	1
Sheep concentrate feed	38.1	15	19	12	12	2	0.9	1
Calculated Nutrient								
	DM	**CP**	**Selulose**	**Ash**	**EE**	**NDF**	**ADF**	**ME Mcal/kg**
Starter concentrate feed	88.05	16.98	6.24	6.78	2.30	20.0	9.0	2.54
Sheep concentrate feed	89.55	19.13	7.59	7.19	2.27	21.0	10.0	2.50

Table 2. Nutrient contents of consumed feeds DM (%).

Feeds/ Roughages	DM	Ash	CP	EE	NDF	ADF	ADL	CL
Starter concentrate feed	90.77	5.62	17.76	2.09	27.68	10.93	2.53	5.92
Sheep concentrate feed	89.97	5.79	19.97	2.12	22.43	13.14	2.95	12.57
Alfalfa hay	91.71	9.30	17.15	1.48	47.56	39.43	6.91	88.31
Meadow hay	90.98	12.12	11.11	1.21	39.52	22.33	2.03	77.33
Barley straw	93.20	7.12	3.56	1.63	66.12	41.56	3.94	31.16

DM: Dry matter, CP: crude protein, EE: ether extract, NDF: neutral detergent fiber, ADF: acid detergent fiber, ADL: acid detergent lignin, CL: crude lignin

Udder and teat measurements were taken using a tape measure before morning milking in the 1st, 2nd, and 4th months of the lactation period. The distance between the two teats and the length of the teats were measured using a caliper. Udder types (Type I, II, III, IV) were determined following Mills' (1982) classification, which identifies four types of udder morphology based on the position of the udder lobes and teats. Type I has non-separated udder lobes and horizontal teats, Type II has separated udder lobes and horizontal teats, Type III has separated udder lobes and both horizontal and inter-vertical teats, and Type IV has separated udder lobes and teats that are grouped as vertical and near-vertical.

The fat extraction, and methylation measurements were conducted following the Bligh and Dyer (1959) and UNE-EN ISO 5509 (2000) protocols. Milk sample fatty acid analysis was carried out using methylation and GC processes. The fatty acids were methylated and analysed using GC-FID in n-hexane in chromatography vials. The analyses were performed using a GC-FID device (Thermo, USA) with an autosampler (Thermo AI 1310). Fatty acid identification was carried out by comparing the peaks observed in the chromatogram with the retention times of the standard used (Kramer et al., 1997). The milk sample analysis included determining the levels of saturated fatty acids (SFA), unsaturated fatty acids (UFA), and polyunsaturated fatty acids (PUFA), as well as the ratios of w-3, w-6, and w-9 fatty acids. Additionally, the atherogenic index (AI), which is an indicator of atherosclerosis risk, was calculated using the formula AI = (C12:0 + 4 × C14:0 + C16:0)/UFA. The thrombogenic index, an indicator of potential blood platelet accumulation in blood vessels, was calculated using the formula [TI = (C14:0 + C16:0 + C18:0)/(0.5 × MUFA) + (3 × n−3) + (0.5 × n−6) + (n−3/n−6))] (Ulbricht and Southgate, 1991).

The lambs' birth weight was measured using an electronic scale sensitive to 50 g within 12 hours of birth. To evaluate the growth performance of the lambs, they were kept with their dams for 15 days after birth and were exclusively fed with mother's milk. After this period, 40 lambs, which had similar birth weights among the single-born lambs, were divided into two groups: the mother's milk feeding group (M) and the mother's milk with creep feeding group (CF). Each group consisted of 10 male and 10 female lambs. The lambs in the M group were exclusively fed with mother's milk, while those in the CF group were fed with mother's milk and provided with starter concentrate and alfalfa hay ad-libitum during the suckling period. The lambs were weaned at approximately 75 days of age. Table 1 also presents the nutritional contents of the starter concentrate. In the CF group, consumption of starter feed and alfalfa hay began two weeks after lambing. The lambs were weighed at 15, 30, 45, 60, and 75 days using an electronic scale with a precision of 50 g.

The data on lactation milk yield, lactation duration, milk fatty acids, milk components, udder and teat traits were analysed using one-way analysis of variance. In cases where differences between groups were found, the Tukey test was applied. Lamb growth data were analysed using the least squares method. The statistical analyses were performed using the SPSS (v22) software package.

RESULTS

Table 3 shows the results of the fertility traits obtained from the study, with a lamb production rate of 85.71% and litter size of 1.141. Table 4 presents that the mean milk production traits of ewes were 69.74±3.17 lt for mean lactation milk yield and 148.14±3.22 days for lactation duration. The effect of lactation number on lactation milk yield and daily milk yield was found to be significant (P<0.01).

Table 5 shows the mean values of udder traits in ewes at different stages of lactation. The effect of lactation days on udder traits was found to be significant (P<0.001, P<0.01). The distribution of ewes according to udder type was as follows: Type I 0%, Type II 3.27%, Type III 64.29%, and Type IV 32.14%.

Tables 6 and 7 present the values for milk fatty acids by month and lactation number. The main

Table 3. Fertility traits and postnatal live weights of Lalahan ewes.

Items	
Ewes exposed to rams (head)	161
Ewes lambing (head)	121
Lambs born (head)	138
Lambing rate (%)	75.15
Lamb production rate (%)	85.71
Litter size	1.141
Postnatal live weights of the ewes (kg, X±Sx)	56.32±0.67

Table 4. Milk production traits of the ewes.

Lactation milk yield (lt)				
Lactation number	n	X±Sx	Min	Max
1	18	61.19±3.14[b]	35.77	86.48
2	16	83.49±7.47[a]	43.24	147.58
3	16	65.39±3.73[b]	40.20	88.97
P		0.008		
Total	50	69.74±3.17	35.77	147.58
Lactation duration (day)				
Lactation number	n	X±Sx	Min	Max
1	18	149.17±3.80	116	171
2	16	148.56±7.41	97	185
3	16	146.56±5.69	117	183
P		0.945		
Total	50	148.14±3.22	97	185
Daily milk yield (lt)				
Lactation number	n	X±Sx	Min	Max
1	18	0.406±0.02[b]	0.224	0.531
2	16	0.560±0.05[a]	0.254	0.869
3	16	0.446±0.02[b]	0.269	0.535
P		0.002		
Total	50	0.469±0.02	0.224	0.869

Means with unlike letters in column differ significantly (P<0.05).

Table 5. The udder traits of Lalahan ewes.

Items	n	Lactation months			P
		1st	2nd	4th	
Udder circumference (cm)	50	48.9±0.7[a]	46.0±0.7[b]	36.4±1.0[c]	<0.0001
Distance between teats	50	17.7±0.3[a]	16.7±0.2[b]	14.9±0.3[c]	<0.0001
Teat lenght	50	2.5±0.1[a]	2.4±0.1[ab]	2.2±0.1[b]	0.002
Teat width	50	1.9±0.1[a]	1.7±0.1[b]	1.6±0.0[b]	0.001

Means with unlike letters in rows differ significantly (P<0.05).

fatty acids in milk during the entire lactation period were palmitic acid (C16:0) (30.80±0.45%), oleic acid (C18:1) (18.78±0.64%), and myristic acid (C14:0) (14.51±0.36%). Several fatty acids, including C4:0, C10:0, C14:0, C14:1, C15:0, C16:0, C16:1, C18:2n6, C20:0, C18:3n6, C18:3n3, C20:2, C22:0, C24:0, C20:5n3 and C22:6n3, showed significant differences among lactation months (P<0.05, P<0.01, P<0.001). In addition, significant differences were found in the means of C4:0 and C20:4n6 among lactation numbers (P<0.05).

Tables 8 and 9 present the sums and ratios calculated from fatty acids by month and number of lactation. The total percentage of saturated (ΣSFA) and unsaturated fatty acids (ΣUFA) did not differ significantly among lactation months, except for poly-unsaturated fatty acids (ΣPUFA) (P<0.001). An increase in the ratio of w3/w6 was observed with advancing lactation month (P<0.001). There was no significant effect of lactation month on the atherogenic index (AI), but the thrombogenic index (TI) decreased significantly (P<0.001) with lactation month. However, there were no significant differences among the groups in terms of lactation number for any of the analysed traits.

Table 6. The milk fatty acid means according to lactation months (%) (X±Sx)

Fatty acids	Lactaion months				P
	1st	2nd	3rd	4th	
Butyric Acid (C4:0)	1.62±0.05[b]	1.89±0.10[ab]	1.85±0.16[ab]	2.22±0.12[a]	0.002
Caproic Acid (C6:0)	2.38±0.12	2.54±0.19	2.26±0.26	2.42±0.19	0.784
Caprylic Acid (C8:0)	2.87±0.21	3.46±0.19	3.13±0.23	3.04±0.14	0.171
Capric Acid (C10:0)	10.78±0.31[a]	8.79±0.81[ab]	6.63±1.10[b]	8.42±0.58[ab]	0.001
Lauric Acid (C12:0)	5.44±0.16	5.59±0.25	5.81±0.27	5.60±0.17	0.673
Myristic Acid (C14:0)	12.98±0.21[b]	13.67±0.42[b]	15.90±0.42[a]	15.62±0.25[a]	<0.001
Myristoleic Acid (C14:1)	0.32±0.04[b]	0.42±0.04[b]	0.57±0.04[a]	0.56±0.04[a]	<0.001
Pentadecanoic Acid (C15:0)	1.00±0.12[b]	1.12±0.12[ab]	1.14±0.13[ab]	1.38±0.02[a]	0.040
cis-10-Pentadecenoic Acid (C15:1)	0.35±0.01	0.35±0.01	0.32±0.02	0.32±0.01	0.125
Palmitic Acid (C16:0)	32.20±0.41[a]	29.85±0.38[bc]	30.36±0.56[b]	28.64±0.44[c]	<0.001
Palmitoleic Acid (C16:1)	0.28±0.04[c]	0.38±0.06[bc]	0.55±0.09[b]	0.98±0.07[a]	<0.001
cis-10-Heptadecenoic Acid (C17:1)	0.38±0.01	0.37±0.02	0.37±0.02	0.33±0.01	0.065
Stearic Acid (C18:0)	8.22±0.26	8.89±0.43	8.47±0.44	8.34±0.23	0.518
Elaidic Acid (C18:1 n9t)	0.08±0.01	0.15±0.03	0.23±0.08	0.07±0.05	0.090
Oleic Acid (C18:1 n9c)	18.26±0.53	19.28±0.61	18.81±0.79	17.86±0.39	0.306
Linoleic Acid (C18:2 n6c)	2.05±0.05[b]	2.15±0.04[b]	1.99±0.06[b]	2.36±0.07[a]	<0.000
Arachidic Acid (C20:0)	0.10±0.00[a]	0.09±0.00[ab]	0.08±0.01[b]	0.08±0.00[ab]	0.042
γ-Linolenic Acid (C18:3 n6)	0.04±0.00[a]	0.02±0.00[b]	0.02±0.01[b]	0.03±0.00[ab]	<0.001
cis-11-Eicoenioic Acid (C20:1)	0.01±0.01	0.00±0.00	0.00±0.00	0.00±0.00	0.565
α-Linolenic Acid (C18:3 n3)	0.14±0.07[c]	0.77±0.08[b]	0.87±0.08[b]	1.32±0.03[a]	<0.001
Heneicosanoic Acid (C21:0)	0.10±0.04	0.03±0.00	0.04±0.01	0.02±0.00	0.060
cis-11,14,17-Eicosadienoic Acid (C20:2)	0.05±0.00[a]	0.01±0.00[c]	0.01±0.00[c]	0.02±0.00[b]	<0.001
Behenic Acid (C22:0)	0.01±0.00[a]	0.00±0.00[b]	0.00±0.00[b]	0.00±0.00[b]	<0.001
Lignoceric Acid (C24:0)	0.01±0.00[b]	0.02±0.00[a]	0.02±0.00[a]	0.03±0.00[a]	<0.001
cis-5,8, 11,14,17-Eicosapentaenoic Acid (C20:5 n3)	0.02±0.00[c]	0.03±0.00[bc]	0.03±0.00[b]	0.05±0.00[a]	<0.001
Nervonic Acid (C24:1)	0.08±0.01	0.09±0.03	0.06±0.01	0.05±0.01	0.336
cis-4,7,10,13,16,19-Docosahexaenoic Acid (C22:6 n3)	0.14±0.01[a]	0.11±0.02[ab]	0.09±0.02[bc]	0.05±0.01[c]	<0.001

Means with unlike letters in rows differ significantly (P<0.05).

Tables 10 provide values for milk fat, non-fat solids, protein, and lactose. The differences in these values were highly significant (P<0.001) among lactation months. The highest milk fat percentage was recorded in the fourth month (4.88±0.27%). The fourth month had the highest protein percentage (6.14±0.13%), while the first month had the highest lactose percentage (6.25±0.07%). Except for lactose percentage (P<0.001), the percentages of fat, non-fat solids, and protein were not significantly affected by lactation number.

Table 11 shows the least squares means for the live weights of lambs at birth and various ages. Except for 180 days (P<0.001), the feeding group did not significantly affect the live weights of the lambs. However, gender had a significant impact (P<0.05, P<0.001) on the ages after 45 days.

DİSCUSSİON AND CONCLUSİON

Two feeding methods were employed to investigate the growth performance of lambs. The results suggest that creep feeding did not have an impact on the growth performance of lambs during the suckling period. There was no significant difference in growth performance between genders at 15, 30, and 45 days, but males had a higher live weight than females at 60 and 75 days. The interaction between feeding group and sex was not found to be significant. The study found that the birth weight of lambs for Akkaraman, Kıvırcık, and their crossbreeds was similar to

Table 7. The milk fatty acid means according to lactation number (%) (X±Sx).

Fatty acids	Lactation number			Total	P
	1	2	3		
Butyric Acid (C4:0)	2.11±0.12[a]	1.94±0.09[ab]	1.69±0.09[b]	1,90±0,06	0.014
Caproic Acid (C6:0)	2.25±0.23	2.57±0.14	2.36±0.13	2,40±0,09	0.364
Caprylic Acid (C8:0)	3.23±0.13	3.20±0.18	2.93±0.17	3,11±0,10	0.374
Capric Acid (C10:0)	9.80±0.52	8.07±0.78	8.65±0.56	8,77±0,38	0.184
Lauric Acid (C12:0)	5.57±0.16	5.79±0.18	5.41±0.18	5,60±0,10	0.287
Myristic Acid (C14:0)	14.53±0.39	14.61±0.36	14.39±0.34	14,51±0,21	0.904
Myristoleic Acid (C14:1)	0.50±0.04	0.48±0.04	0.42±0.04	0,46±0,02	0.372
Pentadecanoic Acid (C15:0)	1.14±0.11	1.19±0.07	1.14±0.09	1,16±0,05	0.912
cis-10-Pentadecenoic Acid (C15:1)	0.34±0.01	0.33±0.01	0.33±0.01	0,34±0,01	0.755
Palmitic Acid (C16:0)	30.02±0.43	29.89±0.47	30.81±0.46	30,25±0,26	0.288
Palmitoleic Acid (C16:1)	0.66±0.11	0.57±0.07	0.46±0.05	0,56±0,04	0.208
Heptadecenoic Acid (C17:1)	0.34±0.01	0.37±0.01	0.37±0.01	0,36±0,01	0.092
Stearic Acid (C18:0)	8.39±0.32	8.06±0.21	8.94±0.32	8,46±0,17	0.075
Elaidic Acid (C18:1 n9t)	0.05±0.01	0.13±0.04	0.17±0.05	0,12±0,02	0.138
Oleic Acid (C18:1 n9c)	17.60±0.49	19.17±0.48	18.54±0.47	18,51±0,28	0.084
Linoleic Acid (C18:2 n6c)	2.19±0.04	2.11±0.06	2.15±0.06	2,15±0,03	0.657
Arachidic Acid (C20:0)	0.09±0.00	0.09±0.00	0.09±0.00	0,09±0,00	0.719
γ-Linolenic Acid (C18:3 n6)	0.03±0.00	0.03±0.00	0.04±0.00	0,03±0,00	0.305
cis-11-Eicoenioic Acid (C20:1)	0.00±0.00	0.00±0.00	0.00±0.00	0,00±0,00	0.604
α-Linolenic Acid (C18:3 n3)	0.70±0.13	0.82±0.09	0.82±0.09	0,79±0,06	0.639
Heneicosanoic Acid (C21:0)	0.05±0.02	0.04±0.01	0.05±0.03	0,05±0,01	0.837
Eicosadienoic Acid (C20:2)	0.03±0.00	0.02±0.00	0.02±0.00	0,02±0,00	0.194
Behenic Acid (C22:0)	0.00±0.00	0.01±0.00	0.00±0.00	0,00±0,00	0.377
Arachidonic Acid (C20:4 n6)	0.10±0.02[b]	0.13±0.02ab	0.17±0.01[a]	0,14±0,01	0.017
Lignoceric Acid (C24:0)	0.02±0.00	0.02±0.00	0.02±0.00	0,02±0,00	0.632
Eicosapentaenoic Acid (C:20:5 n3)	0.04±0.00	0.03±0.00	0.03±0.00	0,03±0,00	0.498
Nervonic Acid (C24:1)	0.08±0.01	0.07±0.02	0.06±0.01	0,07±0,01	0.642
Docosahexaenoic Acid (C22:6 n3)	0.11±0.02	0.07±0.01	0.11±0.01	0,10±0,01	0.073

Means with unlike letters in rows differ significantly (P<0.05).

the values reported by previous studies (Akçapınar et al., 2000; Mundan and Özbeyaz, 2004). However, it was higher than the values reported by Esen and Yıldız (2000), Ünal et al. (2006), Ceyhan et al. (2007), and Türkmen and Çak (2021). The live weights of lambs on the 15th, 30th, and 60th days were higher than the values reported by Esen and Yıldız (2000) and Türkmen and Çak (2021). A difference in growth performance was observed after the weaning period. At 180 days, the live weights of the CF lambs were significantly higher than those of the M group, although both groups were fed on grazing after weaning.

Reproductive traits are widely recognized as crucial for the economic success of a sheep enterprise. Therefore, improving reproductive performance is a key objective for increasing profitability in sheep production. The study conducted on Lalahan ewes showed a lamb production rate of 85.71% and a litter size of 1.141, which is consistent with the findings reported by Ünal et al. (2006) and slightly lower than those reported by Erol et al. (2017). Additionally, the study revealed a significant impact of lactation number on milk yield. According to the study, ewes in their second lactation produced a higher amount of milk compared to those in their first or third lactation. The lactation milk yield was found to be higher than the reported values for the Akkaraman breed

Table 8. Sums, ratios and indexes based on fatty acids of the milk (as percentages of total measured fatty acids) according to lactation months (X±Sx).

Items	Lactation months				P
	1st	2nd	3rd	4th	
ΣSFA	78.91±0.56	76.94±0.70	76.95±0.96	77.08±0.47	0.124
ΣUFA	21.07±0.54	23.04±0.68	22.96±0.93	23.10±0.45	0.060
ΣMUFA	19.76±0.53	21.04±0.66	20.93±0.86	20.17±0.37	0.372
ΣPUFA	2.50±0.09^{c}	3.30±0.11^{b}	3.20±0.11^{b}	4.05±0.10^{a}	0.001
w3	0.29±0.07^{c}	0.91±0.08^{b}	1.02±0.07^{b}	1.45±0.04^{a}	<0.001
w6	2.21±0.06^{b}	2.39±0.04^{ab}	2.19±0.06^{b}	2.60±0.08^{a}	<0.001
w9	18.67±0.52	19.84±0.61	19.63±0.79	18.50±0.38	0.239
w6/w3	11.26±5.55^{a}	3.12±0.33^{b}	2.52±0.37^{b}	1.81±0.07^{b}	<0.001
MCFA	21.50±0.61^{a}	19.94±0.82^{ab}	17.83±1.07^{b}	19.48±0.51^{ab}	0.010
LCFA	76.53±0.62^{b}	77.92±0.80^{ab}	80.05±1.15^{a}	78.12±0.50^{ab}	0.020
VLCFA	0.34±0.04^{a}	0.27±0.04^{ab}	0.25±0.03^{ab}	0.18±0.02^{b}	0.006
AI	4.09±0.13	3.77±0.15	4.26±0.22	4.04±0.12	0.202
TI	4.46±0.12^{a}	3.46±0.09^{bc}	3.59±0.14^{b}	3.11±0.07^{c}	<0.001
h:H	0.46±0.01^{b}	0.52±0.02^{a}	0.48±0.02^{ab}	0.50±0.01^{ab}	0.050

Means with unlike letters in rows differ significantly (P<0.05).SFA Saturated fatty acids, MUFA Monounsaturated fatty acids, PUFA Polyunsaturated fatty acids, UFA unsaturated fatty acids, MCFA Medium-chain fatty acids, LCFA Long-chain fatty acids, VLCFA Very-long chain fatty acids, AI Atherogenic index, TI Thrombogenic index, h:H hypocholesterolaemic and hypercholesterolaemic fatty acids ratio

Table 9. Sums, ratios and indexes based on fatty acids of the milk (as percentages of total measured fatty acids) according to lactation numbers (X±Sx).

Items	Lactation number			Total	P
	1	2	3		
ΣSFA	78.40±0.57	76.95±0.60	77.39±0.55	77.52±0.34	0.359
ΣUFA	21.69±0.55	23.09±0.59	22.55±0.53	22.51±0.33	0.127
ΣMUFA	19.56±0.50	21.14±0.53	20.37±0.48	20.42±0.30	0.104
ΣPUFA	3.21±0.12	3.21±0.14	3.39±0.15	3.27±0.08	0.579
w3	0.85±0.12	0.91±0.09	0.98±0.09	0.92±0.06	0.666
w6	2.36±0.05	2.30±0.07	2.41±0.07	2.36±0.04	0.470
w9	18.14±0.48	19.80±0.49	19.15±0.46	19.10±0.28	0.065
w6/w3	11.12±5.46	4.51±0.89	4.20±0.74	6.27±1.61	0.873
MCFA	20.86±0.63	19.65±0.71	19.08±0.63	19.79±0.39	0.186
LCFA	76.76±0.66	78.18±0.71	78.95±0.63	78.05±0.39	0.085
VLCFA	0.28±0.04	0.22±0.03	0.28±0.03	0.26±0.02	0.341
AI	4.17±0.13	3.94±0.12	4.02±0.15	4.03±0.08	0.493
TI	3.81±0.15	3.56±0.14	3.65±0.12	3.66±0.08	0.417
h:H	0.47±0.01	0.50±0.02	0.49±0.01	0.49±0.01	0.206

Means with unlike letters in rows differ significantly (P<0.05).

SFA Saturated fatty acids, MUFA Monounsaturated fatty acids, PUFA Polyunsaturated fatty acids, UFA unsaturated fatty acids, MCFA Medium-chain fatty acids, LCFA Long-chain fatty acids, VLCFA Very-long chain fatty acids, AI Atherogenic index, TI Thrombogenic index, h:H hypocholesterolaemic and hypercholesterolaemic fatty acids ratio

Table 10. The milk compositions according to month and number of lactation (%) (X±Sx).

Components	Lactation months				P
	1st	2nd	3rd	4th	
Fat	3.55±0.12[b]	3.78±0.20[b]	5.10±0.30[a]	5.97±0.43[a]	<0.001
Non-fat solids	11.36±0.12[bc]	11.07±0.06[c]	11.91±0.14[a]	11.72±0.17[ab]	<0.001
Protein	4.16±0.04[d]	4.80±0.11[c]	5.42±0.20[b]	6.14±0.13[a]	<0.001
Lactose	6.25±0.07[a]	5.26±0.08[b]	5.49±0.22[b]	4.61±0.13[c]	<0.001
	Lactation numbers				
	1	2	3		
Fat	4.43±0.29	4.81±0.30	4.61±0.33		0.642
Non-fat solids	11.76±0.20	11.31±0.11	11.52±0.14		0.112
Protein	4.95±0.24	5.19±0.16	5.42±0.20		0.261
Lactose	5.91±0.21[a]	5.17±0.14[b]	5.08±0.14[b]		0.001

Table 11. The least squares means of live weights of lambs at the different ages (kg) (X±Sx).

Items	n	Birth	15	30	45	60	75	180
		X±Sx	X±Sx	X±Sx	X±Sx	X±Sx	X±Sx	X±Sx
Group		0.798	0.307	0.543	0.824	0.979	0.964	0.007
CF	20	4.85±0.16	8.90±0.27	12.55±0.34	15.42±0.41	17.76±0.42	20.98±0.51	31.66±0.82
M	20	4.91±0.17	9.30±0.28	12.85±0.36	15.55±0.43	17.74±0.44	20.95±0.54	28.23±0.87
Gender		0.971	0.394	0.073	0.167	0.035	0.030	0.000
Male	20	4.88±0.16	9.27±0.28	13.15±0.35	15.90±0.42	18.42±0.43	21.80±0.52	32.91±0.85
Female	20	4.88±0.16	8.93±0.28	12.24±0.35	15.07±0.42	17.08±0.43	20.13±0.52	26.98±0.84
Group x Gender		0.635	0.669	0.145	0.342	0.490	0.458	0.619
Total	40	4.88±0.11	9.10±0.20	12.70±0.25	15.49±0.30	17.75±0.30	20.97±0.37	29.94±0.60

CF the maternal milk with creep feeding group, M the maternal milk feeding group

(Ünal et al., 2002; Mundan and Özbeyaz, 2004), but lower than the values reported by Aşkan and Aygün (2020) and Kahraman and Özkul (2020). According to previous studies, it has been found that local and crossbred sheep genotypes can produce milk yields ranging from 70-150 litres during the entire lactation period (Ünal et al., 2002; Mundan and Özbeyaz, 2004; Ceyhan et al., 2007; Alarslan and Aygün, 2019; Akgün and Koyuncu, 2020). It is worth noting that the milk yield of sheep is influenced by various factors such as breed, age, condition, and nutrition. The study observed that the lactation milk yield fell within the range expressed for meat-type breeds. It is possible that the difference may be attributed to variations in animal care and feeding conditions.

It has been observed that the daily milk yield is affected by similar factors as the lactation milk yield. Studies have indicated that the Lactation number can have an impact on the daily milk yield. In particular, it has been noted that the daily milk yield of ewes during their second lactation was higher than during other lactations. The daily milk yield of this study was found to be higher than that reported for KıvırcıkxAkkaraman F1 and KıvırcıkxAkkaraman B1 genotypes by Ünal et al. (2002). It was similar to the values reported for Kıvırcık genotypes by Akgün and Koyuncu (2020), but lower than the value reported for Akkaraman genotype by Kahraman and Özkul (2020). It is believed that these variations may arise due to differences in the care and feeding conditions, which can impact the efficiency of lactation.

Based on the research conducted, it has been found that the lactation period is not affected by the number of lactations, and it remains similar across all groups. The lactation period values obtained from the study are consistent with the findings of Mundan and Özbeyaz (2004), Akgün and Koyuncu (2020), and Kahraman and Özkul (2020), but lower than those reported by Aşkan and Aygün (2020). It is commonly believed that the lactation period is similar across local sheep breeds.

Regarding udder characteristics, it is worth noting that as lactation progresses, udder size tends to decrease, which is thought to be associated with a decrease in milk production capacity. The present study compared the distance between teats and the teat length with the literature, and the results were consistent with those reported by Mundan and Özbeyaz (2004), Yüceer et al. (2015), and Akgün and Koyuncu (2021). The circumference of the udder was lower than the value reported by Akgün and Koyuncu (2021), but similar to the findings of Mundan and Özbeyaz (2004) and Yüceer et al. (2015). Additionally, the high occurrence of Type III and Type IV in relation to udder type suggests that it may be well-suited for machine milking.

Regarding the analysis of milk fatty acids, it was observed that the highest levels of C10:0, C16:0, C20:0, C18:3n6, C20:2, C22:0, C24:0, and C22:6n3 were found during the first month after birth. Conversely, the highest levels of C14:0 and C14:1 were observed during the third and fourth months. Additionally, C4:0 was found to be the highest in the milk during the first month, while C20:4n6 was the highest in the milk during the fourth month, according to lactation numbers. The quality, texture, aroma, and flavor of milk and its products can be influenced by the profile and content of fatty acids, as noted by Yurchenko et al. (2018). The study ensured that all animal groups received identical care and feeding conditions. The observed difference in fatty acid profile is attributed to the intensive and concentrated feed given during the first month of lactation, followed by a diet of roughage while on pasture during the remaining months.

The study found that during the first month of milking, levels of MCFA, VLCFA, and TI were highest, while h:H was highest in the second month. LCFA levels peaked in the third month, and PUFA, w-3, w-6, and w-3/w-6 were highest in the fourth month. It was noted by Cabiddu et al. (2005) that green feeds are particularly rich sources of PUFA. Additionally, Markiewicz-Kęszycka et al. (2013) identified breed, feeding, individual differences, and lactation period as factors that affect milk fat. It is possible that the increase in PUFA values observed after the animals began grazing on the pasture could be linked to the consumption of green grass and the change in the lactation period. The SFA values in this study were higher than those reported by some previous studies, including Cabiddu et al. (2005), Signorelli et al. (2008), Markiewicz-Kęszycka et al. (2013), Özkaya et al. (2018), and Kahraman and Yüceer Özkul (2020), but similar to those reported by Nudda et al. (2014) and Sinanoglou et al. (2015). Similarly, the amount of UFA reported in this study is comparable to that reported by Cabiddu et al. (2005) and Sinanoglou et al. (2015), but appears to be lower than the amount reported by Özkaya et al. (2018). The MUFA values in this study were found to be lower than those reported by some previous studies, such as Signorelli et al. (2008), Markiewicz-Kęszycka et al. (2013), Özkaya et al. (2018), and Kahraman and Yüceer Özkul (2020). However, they were similar to those reported by Cabiddu et al. (2005) and Sinanoglou et al. (2015), and higher than those reported by Nudda et al. (2014). The study's PUFA values differed from those reported by various authors, including Addis et al. (2005), Signorelli et al. (2008), Markiewicz-Kęszycka et al. (2013), Sinanoglou et al. (2015), Özkaya et al. (2018), and Kahraman and Yüceer Özkul (2020). However, they were similar to the values reported by Cabiddu et al. (2005) and higher than those reported by Nudda et al. (2014). The AI and TI values obtained in this study were higher than those reported by Markiewicz-Kęszycka et al. (2013), Sinanoglou et al. (2015), and Kahraman and Yüceer Özkul (2020). It is believed that breed and nutrition are the main factors contributing to the differences in these values when evaluating all studies (Markiewicz-Kęszycka et al., 2013).

Sheep milk is known for its characteristic flavors in cheeses due to the presence of short-chain fatty acids, such as butyric acid, and medium-chain fatty acids (MCFAs) (Mollica et al., 2021). Compared to other ruminant milk, sheep milk has a higher concentration of butyric acid (C4:0) and w-3 FAs (Mohapatra et al., 2019). The study conducted by Goudjil et al. (2004) found that the level of butyric acid increased as lactation progressed for Lalahan sheep, which could affect the characteristic odor of the milk. According to Cividini et al. (2019), the milk of Lalahan sheep contains twice as much capric and lauric acids compared to Bovec sheep milk. Additionally, the ratio of caprylic, caproic, and butyric acids in Lalahan sheep milk is three times higher than in Bovec sheep milk. According to Nguyen et al. (2019), the lauric acid content of Lalahan sheep milk remains consistent throughout the lactation period, averaging at 5.60%. This is twice as high as that of Awassi and Awassi × East Friesian crossbred ewes (in mid lactation breed) which have an average of 2.7%. The study found that the ratio of MCFAs (myristic, myristoleic lauric, capric and caproic acids) in the total milk fat was, on average, 19.79%. Although this ratio varied according to the months of lactation, it did not change with the number of lactations. Therefore, it can be concluded that the characteristic odor of the cheeses made from the milk of Lalahan sheep will remain consistent regardless of the number of lactations.

The study found that the ratios of ΣPUFA, ΣMUFA, w-3, w-6 and w-9 fatty acids in the total fatty acids in the milk of Lalahan sheep were within the reference values for sheep breeds (Mollica et al., 2021). The increase in the ΣPUFA (w-3 and w-6) ratio in milk fat from the 1st to the 4th month of lactation indicates an increase in the nutritional value of the milk, despite the sheep being fed a similar ration. The high UFA and low SFA content of the milk is desirable for human health (Alizadehasl and Ünal, 2021). Studies aimed at increasing daily consumption of w-3 and w-6 fatty acids, known to have positive effects on human health, and reducing saturated fatty acids in the diet, aim to increase the fatty acid profile in animal products in favor of unsaturated fatty acids. The TI value reflects the increase in this fatty acid profile as lactation progresses, and decreases to a satisfactory level. The higher h:H ratio in the second month of lactation suggests that the milk obtained during this period will have a lower effect on cholesterol, making it a functional milk. It is important to note that the decrease in the fatty acid profile may vary depending on the breed of the sheep and environmental factors such as temperature and shelter conditions, in addition to the month of lactation. It has been demonstrated that the fatty acid profiles of Lalahan sheep are not affected by the number of lactations, indicating that the age of the animal does not have a negative impact on milk composition.

The milk components of Lalahan ewes, including fat, non-fat solids, protein, and lactose, showed significant differences depending on the month of milking. Fat and protein levels increased from the first month after birth and peaked during the fourth month of milking, while non-fat solids were highest during the third month. In contrast, lactose levels gradually decreased, with the highest levels observed during the first month of milking. Upon examining the milk components in relation to the number of lactations of the sheep, it was observed that the levels of fat, non-fat solids, and protein remained constant. However, the level of lactose was found to be highest in sheep during their first lactation and decreased with each subsequent lactation. Based on the study's findings, the fat values are comparable to those reported by Ocak et al. (2009), Akca and Bakır (2017), and Aşkan and Aygün (2020), but lower than those reported by Doğan et al. (2013), Alarslan and Aygün (2019), Akgün and Koyuncu (2020), Göncü et al. (2022), and Kahraman and Özkul (2020). In relation to non-fat solids, the value was higher than that reported by Akca and Bakır (2017) and similar to the values reported by Ocak et al. (2009), Doğan et al. (2013), Alarslan and Aygün (2019), Akgün and Koyuncu (2020), and Göncü et al. (2022). The protein value of the study was lower than the values reported by Ocak et al. (2009) and Alarslan and Aygün (2019), but similar to the values reported by Doğan et al. (2013), Akca and Bakır (2017), Akgün and Koyuncu (2020), Aşkan and Aygün (2020), Kahraman and Özkul (2020), and Göncü et al. (2022). The study found that the lactose content was lower than the value reported by Akca and Bakır (2017), which is consistent with the findings of Doğan et al. (2013) and Kahraman and Özkul (2020), but higher than that reported by Alarslan and Aygün (2019), Akgün and Koyuncu (2020), Aşkan and Aygün (2020), and Göncü et al. (2022).

CONCLUSİON

It has been determined that the milk yield of Lalahan sheep, which were bred for the purpose of raising meat-type lambs adapted to steppe conditions, is similar to that of meat-type sheep breeds. Furthermore, their udder type is suitable for machine milking. The fatty acids in their milk are of high quality for sheep milk, and the milk components are within normal values for sheep milk. Additionally, it was observed that the growth performance of lambs raised on maternal milk and creep feeding was comparable. However, the performance of lambs fed on creep feeding was superior after weaning.

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AUTHOR CONTRİBUTİON

All authors contributed to the study conception and design. Material preparation, data collection performed by Hasan Hüseyin ŞENYÜZ, Yasin ERGİDEN, Çağatay YILDIRIM, Ömer Onur PARILDAR, Feridun Işın CONER, Sinem FIRDOLAŞ, Muhammed İkbal COŞKUN, Ezgi ODABAŞ, Fatmagül MIZRAK, Yusuf ZENGİN, Halil EROL and analysis were performed by Hasan Hüseyin Şenyüz, Muhammed İkbal COŞKUN, Kanber KARA and Necmettin ÜNAL. *The first draft of the manuscript was written by Hasan Hüseyin Şenyüz,* and Necmettin ÜNAL *and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.*

CONFLİCT OF İNTEREST

The authors declare no conflict of interest.

DATA AVAİLABİLİTY

The datasets generated during and/or analysed during the current study are not publicly available due to government farm but are available from the corresponding author on reasonable request.

ANİMAL WELFARE STATEMENT

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to and the appropriate ethical review committee approval has been received. The authors confirm that they have followed EU standards for the protection of animals used for scientific purposes. This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of International Center for Livestock Research and Training (Date 2019/No 172).

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