The investigation of milk yield, composition, quality, and fatty acids in Angora goats based on rangeland feeding conditions

MAZIAR ALIZADEHASL[1], NECMETTIN UNAL*[2]

[1]Graduate School of Health Sciences, Ankara University, Ankara, Turkey
[2]Department of Animal Breeding and Husbandry, Faculty of Veterinary Medicine, Ankara University, Ankara, Turkey

SUMMARY

The study aimed to survey milk yield, composition, some quality characteristics, and fatty acids in Angora goats fed at rangeland conditions. The traits investigated were examined for lactation number (LN; 1, 2, and 3+), lactation stage (LS; early, middle, and late), and milking time (MT; morning and evening). The daily milk yields were determined as 415.60±21.58, 496.73±17.39, and 533.60±18.14 g (P<0.001), and the lactation milk yields were defined as 71.57±4.35, 90.15±3.25, and 96.31±3.99 kg (P<0.001) in the goats with LN 1, 2, and 3+, respectively. Milk chemical composition (fat, protein, lactose, and dry matter) changed significantly (P<0.05, P<0.01, P<0.001) because of LN, LS, and MT. The milk pH values were not varied significantly by LN, however, varied by LS (P<0.001) and MT (P<0.01) importantly. While LN did not affect the milk color coordinates, the effects of LS on a* values (P<0.001) and MT on a* and b* values (P<0.001) were prominent. The majority of fatty acids did not differ significantly among LN but differed importantly (P<0.05, P<0.01, P<0.001) due to the LS. Almost half of the total fatty acids consisted of palmitic (C16:0) + oleic (C18:1) acids, and the mean SFA ratio was 70.954±0.365% during the entire lactation period. Fatty acids responsible for odor specific to goat milk have decreased in the late stage of lactation. The ratios of ω6/ω3 were below the limit value of four during the lactation period. The results revealed that the milk production traits of Angora goats based on rangeland feeding conditions were higher than the averages accepted for the breed, with the acceptable values for milk composition and quality characteristics. Fatty acid compositions varied throughout the lactation period, including an increase in SFA and a decrease in UFA.

KEY WORDS

Angora goat, milk quality, milk yield, rangeland feeding, fatty acid.

INTRODUCTION

Angora goat is a world-famous goat breed with its unique mohair production. It has been bred in lots of countries such as Turkey, the United States of America, Australia, and South Africa for a long time, and this breed was originated from the region of Ankara, the capital city of Turkey. The number of Angora goats in Turkey decreased continuously from 6 million heads in 1960 to 1.2 million heads in 1990, and to 147 thousand in 2009, the lowest population in history; then, it started to increase due to support of breeding and mohair production and reached 241 thousand heads in 2019[1]. Some socio-economic factors, including the low price for mohair, reducing rangeland, migration from rural to urban have been effective in declining the number of Angora goats. In particular, the decrease in income from mohair, the primary product, is the main issue among the problems. Thus, in recent years, the utility of meat and milk yields of Angora goats has come to the fore.

Angora goat is a small-sized breed. It was well adapted to continental climate conditions. The goats are generally managed extensively, depends upon pastures, rangelands, and cereal stubbles. They also utilize shrubbery areas. Angora goats have the ability to walk long in the rangeland and benefit from rugged pasture, and spend most of the year in these areas[2].

The investigations on Angora goat in Turkey generally focused on yield, quality, and improvement of the mohair. Besides, the researches on reproductive performance of goats, and survival and growth of kids were also conducted. However, the yield, quality, and composition of Angora goat milk are poorly characterized; one research[3] about the entire lactation milk yield of the breed in Turkey has been carried out at the flock raised under semi-intensive conditions. Although the feeding of Angora goats was mainly based on rangelands, there is no scientific report on the yield, composition, quality, and fatty acid composition of the milk during the entire lactation period.

The yield and contents of goat milk could be affected by a wide of factors such as breed, stage of lactation, season and year, lactation number, diet, feeding and management conditions, milking time, and system of production[3,4,5,6,7,8]. On average, goat milk contains 12-13% dry matter, consisting of about 3.8% fat, 3.5% protein, 4.1% lactose, and 0.8% minerals[4]. It was expressed that researches on milk composition of goats were restricted and primarily intensified on dairy goat breeds. It is necessary to make systematic studies for defining the quality of goat milk[4].

Daily milk yield of 548-926 g, the fat ratio of 4.93-5.67%, and protein ratio of 4.06-4.16% have been reported for the 3-16

Corresponding Author:
Necmettin Unal (unaln@ankara.edu.tr)

weeks of the lactation period in Angora goats fed intensively with diets formulated with different crude protein levels[5]. The recent research by McGregor[6], daily milk yield, fat, protein, and lactose of the milk for Angora goats, fed with concentrate *ad libitum*, were notified as 1.74 kg, 8.92%, 3.71%, and 5.48% on the 42nd day of lactation period, respectively.

Milking of hair goats, the main breed of goat population in Turkey, is a general practice, although the majority of Angora goat flocks are not milked, the reasons for this being a long suckling period and poor milk production. On the other hand, some breeders have utilized from Angora goat in terms of milk yield in recent years. Milk obtained from Angora goats by hand milking or machine milking is partly used locally for the nutritional needs of the rural owners, and excess milk is used for cheese making. Thus, it is important to examine both milk yield and milk quality characteristics of Angora goats, whose feeding is usually based on rangeland. The hypothesis in this research was that the characteristics of milk production and the quality of Angora goats fed at rangeland conditions might enable them to benefit for milk yield.

This research was conducted to investigate milk yield, content, some milk quality characteristics, and fatty acid composition at the different stages of lactation in Angora goats fed at rangeland conditions.

MATERIALS AND METHODS

The Animal Research Local Ethics Committee of Ankara University approved all procedures applied in the current study (Approval number: 2015-4-72).

Animals and managements

The research was carried out at a private farm, in Ayaş district of Ankara province, in the Central Anatolian Region of Turkey, where a semiarid continental climate prevails. The farm is located at 40° N and 32° E and an altitude of 910 m above sea level.

The farm kept about 900 Angora goats from different lactation numbers in the 2015 year. Kiddings took place between March 1st and April 10th, 2015, and intensified around March 15-25th. The animal material of the research was formed of a total 46 Angora goats, 13 and 15 and 18 heads from the lactation number 1 and 2 and 3+, selected randomly from this flock. All the research goats had a single kid and gave birth on the same day, March 17, 2015. Since no goats have been used as a dairy goat, the kids were allowed to suckle their mothers during the entire lactation period to maintain lactation. Data for milk yield of two goats from lactation number 1 and 3+ were not obtained after 75th and 105th days of lactation, respectively, because of drying off due to the death of their kids. The milk samples for determining the quality characteristics of milk were taken from 10 heads, selected randomly, from each lactation number group of the study. The milk samples were taken from the morning (around 08:00 am) and evening (around 06:00 pm) milking at the early (45th day), middle (75th day), and late (135th day) stages of lactation.

All the research goats were managed with the farm flock. The goats were offered a mixture feed of sunflower with 100 g/day/head and barley with 250 g/day/head and roughage (barley straw with *ad libitum*) for six weeks before kidding. The goats were kept in shelter during the winter season. During the first month of lactation, indoor keeping from March 17 to April 17, the same feeding of late gestation period was also applied. The sunflower and barley included 88.75 and 91.00% dry matter, 14.7 and 11.5% crude protein, 5.25 and 5.00% crude cellulose, 1.95 and 1.90% crude fat, 3.2 and 2.5% crude ash, and 2.72 and 2.85 Mcal/ kg dry matter, respectively. From the beginning of the second month to the end of the lactation, the goats were fed only from rangeland, and no additional feed was given. Since 10 July, the goats were also utilized from cereal stubbles. In the morning, the goats were taken to the rangeland and stayed during the day and were brought back to the house in the evening. The goats were kept under shades in the hot hours of the daytime during summertime. The flock was shepherded all the time during grazing. Thus, the sedentary system was applied for herd keeping.

Kidding took place in a littered floor building with ambient temperature. Routine kid management after kidding, such as iodine treatment of the navel, injection of Vitamin E – Selenium, ear tagging was practiced. The kids were kept with their dams following the birth and allowed to suckle their mothers. After two months of age, the kids were gone to the rangeland with their mothers until the end of lactation. The milk obtained on control days was used for feeding the kids.

The vegetation in the region was composed of grasses, legumes, and other plant families with a portion of 49.64% and 11.97% and 38.39%, respectively. The most frequent plant species were *Festuca ovina* (23.66%) and *Koeleria cristata* (10.23%) from 13 species in grasses; *Astragalus angustifolius* (4.21%) and *Astragalus lycius* (1.94%) from 10 species in legumes; *Thymus sipyleus* (11.34%) and *Veronica multiflora* (6.08%) from 19 species in other plants families[9].

Data collection

Measurements of milk yield were initiated 2 weeks later after the kidding and continued at 4 weeks intervals. The kids were separated from their dams overnight, 12 hours prior to milking. Following a 12 hours separation, the goats were milked by hand milking (morning milking). The hand-milking process was performed again after 12 hours (evening milking). Milk yield was individually recorded for each goat for 24 hours periods. The amount of milk after milking was measured using an electronic scale (precision: 5 g). The data for the lactation curves at 30th, 60th, 90th, 120th and 150th days were calculated by interpolation method. Individual milk yield per lactation was calculated from the data collected on control days by using Trapeze II Method[10].

During the research, environmental temperatures (minimum and maximum) and relative humidity published by Meteorological Services were recorded daily for the place where the research was conducted.

The milk chemical composition and somatic cell count both morning and evening milk were determined using Milk Analyser (Bentley 150 Combi). Milk fat, protein, lactose, and dry matter were defined with an Infrared Milk Analyzer (Bentley 150) using an optical infrared analysis system; somatic cell count was detected with Somatic Cell Count Analyser (Bentley Somacount 150) using flow cytometry method. Milk pH and color analyses were made in fresh milk samples; fatty acid composition analysis was undertaken in frozen milk cream samples kept at −18°C.

Milk pH was measured with a portable pH meter (Metler Toledo SG2 with an Inlab 427 probe) after milking. Meat color was estimated using the CIE-*L*a*b** system with a chromameter Konica Minolta CR-400 after milking. The CIE-*L*a*b** places the color coordinates in a uniform color space with L* (lightness; from 0 to 100 on a scale, 0: black and 100: white), a* (redness; −a*: green color and +a*: red color), and b* (yellowness; −b*: blue color and +b*: yellow color)[11].

For fatty acids analysis, equal amounts of milk samples (50 ml) from morning and evening milk were centrifuged for 30 min, 4000 rpm at +4 °C, and milk cream from the top of the tube was gathered in 1.5 ml vials, and frozen at -18 °C until analysis. During analysis, approximately 200 µl milk cream was saponified with 0.5 ml of 2N methanolic KOH for 2 min/ mixed at room temperature. Later, 5 ml n-Heptane was added, vortexed for 2 min, and a few mg of anhydrous Na^2SO^4 was added. Later, tubes were centrifuged at 800 rpm/3 min and allocated to separate an organic phase. Fatty acid methyl esters (FAME) were collected from the top layer and transferred into vials. Separation of fatty acids was performed with HP Agilent 6890/5972 model GC-MS equipped with HP Innowax colon (60 m length, 0.25 mm i.d. x 0.25 µm film). While the injector temperature was set at 250 °C, the detector temperature was 270 °C. The split ratio of injection was 1:50, and the total injection volume of 1 µl. The injector was washed three times with n-Heptane before each injection. The oven temperature was programmed initially at 150 °C for 3 min and was increased to 240 °C with a 3 °C/min ramp rate. Helium was used as a carrier gas. The separation length was continued as 40 min. Detected picks were corrected with FAME Mix C4-24, Sigma after MS detection. Moreover, the nutritive value (NV), the atherogenic index (AI), and the thrombogenic index (TI) were calculated according to the formulas suggested by Ulbricht and Southgate[12].

Statistical analysis

Daily milk yield and milk production traits were analysed using one-way ANOVA with Tukey's HSD test. Data for milk composition, some milk quality characteristics, and fatty acid composition were analysed using Least Squares Mixed Model Procedures of SPSS 23.0 statistical software, and the analytical models were as follows:

$y_{ijkl} = \ + anim_i + LN_j + LS_k + MT_l + LN_jxLS_k + LN_jxMT_l + LS_kx MT_l + LN_jxLS_kx MT_l + e_{ijkl}$ (for milk composition and some milk quality characteristics)

$y_{ijk} = \ + anim_i + LN_j + LS_k + LN_jxLS_k + e_{ijk}$ (for fatty acid composition and sums and indexes based on fatty acids)

in which y_{ijkl}: each trait, : overall mean, $anim_i$: the random effect of the *i*th animal, LN_j: the fixed effect of *j*th lactation number (1, 2, and 3+), LS_k: the fix effect of *k*th lactation stage (early, middle, late), MT_l: the fixed effect of the *l*th milking time (morning and evening), e_{ijkl}: 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. Post-hoc testing for significant interactions was performed using simple effect analysis with Bonferroni adjustment. In cases where the interaction term was not statistically significant, Tukey's HSD test was used to analyse the main effects. A probability value of less than 0.05 was considered significant.

RESULTS

The means measured by the General Directorate of Meteorology for the region of Ayaş, the study was carried out, are shown in Figure 1, and daily milk yield and milk production traits are

Table 1 - Means (± SEM) daily milk yield (g) and milk production (kg) traits.

LN	Daily milk yield at the different days of lactation period (g)						
	Means	15	45	75	105	135	165
1	n	13	13	12	12	12	12
	X±Sx	497.31±23.22a	631.46±41.69a	545.00±44.75a	379.67±31.27a	252.67±15.78a	85.67±8.81a
2	n	15	15	15	15	15	15
	X±Sx	579.67±24.86b	781.87±34.30b	689.00±30.12b	484.87±23.96b	332.67±20.12b	120.33±8.79b
3+	n	18	18	18	17	17	17
	X±Sx	649.17±22.16c	865.61±40.90b	699.17±36.52b	490.76±26.32b	343.41±24.32b	122.06±11.29b
P		<0.001	0.001	0.003	0.013	0.014	0.033
TOTAL	n	46	46	45	44	44	44
	X±Sx	583.59±16.13	772.13±26.43	654.67±23.15	458.45±16.91	315.00±13.48	111.55±6.18

LN	Entire lactation period			
	Means	Daily milk yield (g)	Lactation duration (day)	Milk production (kg)
1	n	12	12	12
	X±Sx	415.60±21.58a	171.50±2.70a	71.57±4.35a
2	n	15	15	15
	X±Sx	496.73±17.39b	181.53±2.33b	90.15±3.25b
3+	n	17	17	17
	X±Sx	533.60±18.14b	179.82±2.16b	96.31±3.99b
P		<0.001	0.016	<0.001
TOTAL	n	44	44	44
	X±Sx	488.84±12.88	178.14±1.48	87.47±2.67

Means with unlike letters in columns (a, b, c) differ significantly (P<0.05). LN Lactation number.

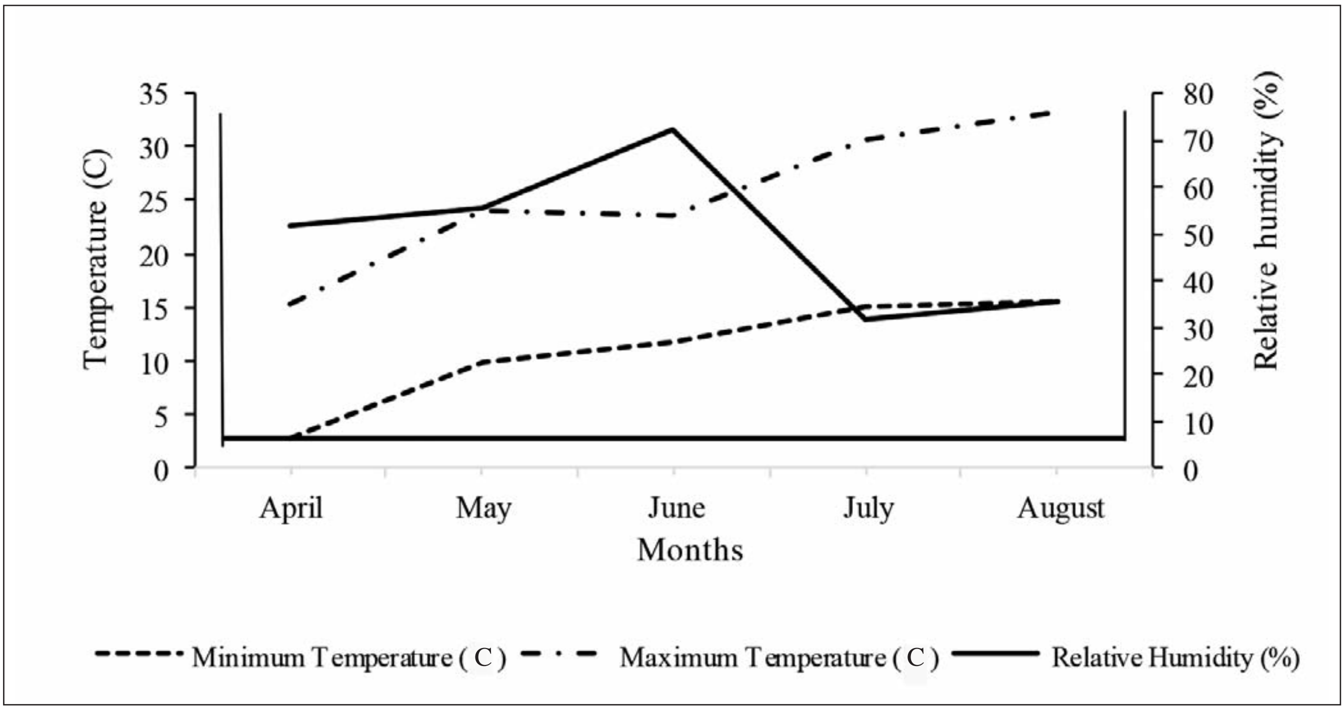

Figure 1 - The graphics for temperatures with relative humidity's at the farm during the study.

given in Table 1. While the daily milk yield during the entire lactation period was 415.60±21.58, 496.73±17.39, and 533.60±18.14 g ($P<0.001$), the milk yield were 71.57±4.35, 90.15±3.25, and 96.31±3.99 kg ($P<0.001$) for LN 1, 2, and 3+, respectively. The lactation curves for daily milk yield of the goats as measured by LN are shown in Figure 2. The milk yield of the goats peaked around the 6th week of lactation.

Milk chemical composition and somatic cell counts (SCC) values are presented in Table 2. While milk fat ratios were among 4.23-5.26%, and it was affected by LN ($P<0.001$), LS

Table 2 - Least squares means (±SE) of milk chemical composition and SCC.

Items	Fat (%)	Protein (%)	Traits Lactose (%)	Dry matter (%)	SCC (x10^3/ml)
LN					
1	5.26±0.17a	4.15±0.05a	4.91±0.05a	15.46±0.19a	328.39±65.90
2	4.89±0.16a	3.96±0.04b	4.97±0.04ab	15.00±0.18ab	251.84±65.25
3+	4.23±0.16b	4.16±0.04a	5.05±0.04b	14.62±0.18b	166.95±64.22
P	<0.001	0.005	0.119	0.007	0.218
LS					
Early	4.37±0.15a	4.26±0.05a	4.99±0.04a	14.81±0.17a	531.61±61.17a
Middle	5.15±0.16b	3.96±0.04b	5.15±0.05a	15.42±0.18b	124.43±63.58b
Late	4.85±0.18ab	4.05±0.05b	4.79±0.05b	14.86±0.20a	91.14±70.29b
P	0.002	<0.001	<0.001	<0.035	<0.001
MT					
Morning	3.38±0.13	3.99±0.04	5.09±0.04	13.58±0.15	125.66±53.18
Evening	6.21±0.13	4.19±0.04	4.87±0.04	16.48±0.15	372.47±53.18
P	<0.001	<0.001	<0.001	<0.001	<0.001
Interactions					
LNxLS	0.707	0.306	0.041	0.507	0.131
LNxMT	0.290	0.870	0.835	0.438	0.315
LSxMT	0.090	0.404	0.078	0.042	0.142
LNxLSxMT	0.650	0.997	0.790	0.792	0.715
TOTAL	4.79±0.10	4.09±0.03	4.98±0.03	15.03±0.11	249.06±37.60

Means with unlike letters in columns (a, b) differ significantly ($P<0.05$). LN Lactation number, LS Lactation stage, MT Milking time, SCC Somatic cell count.

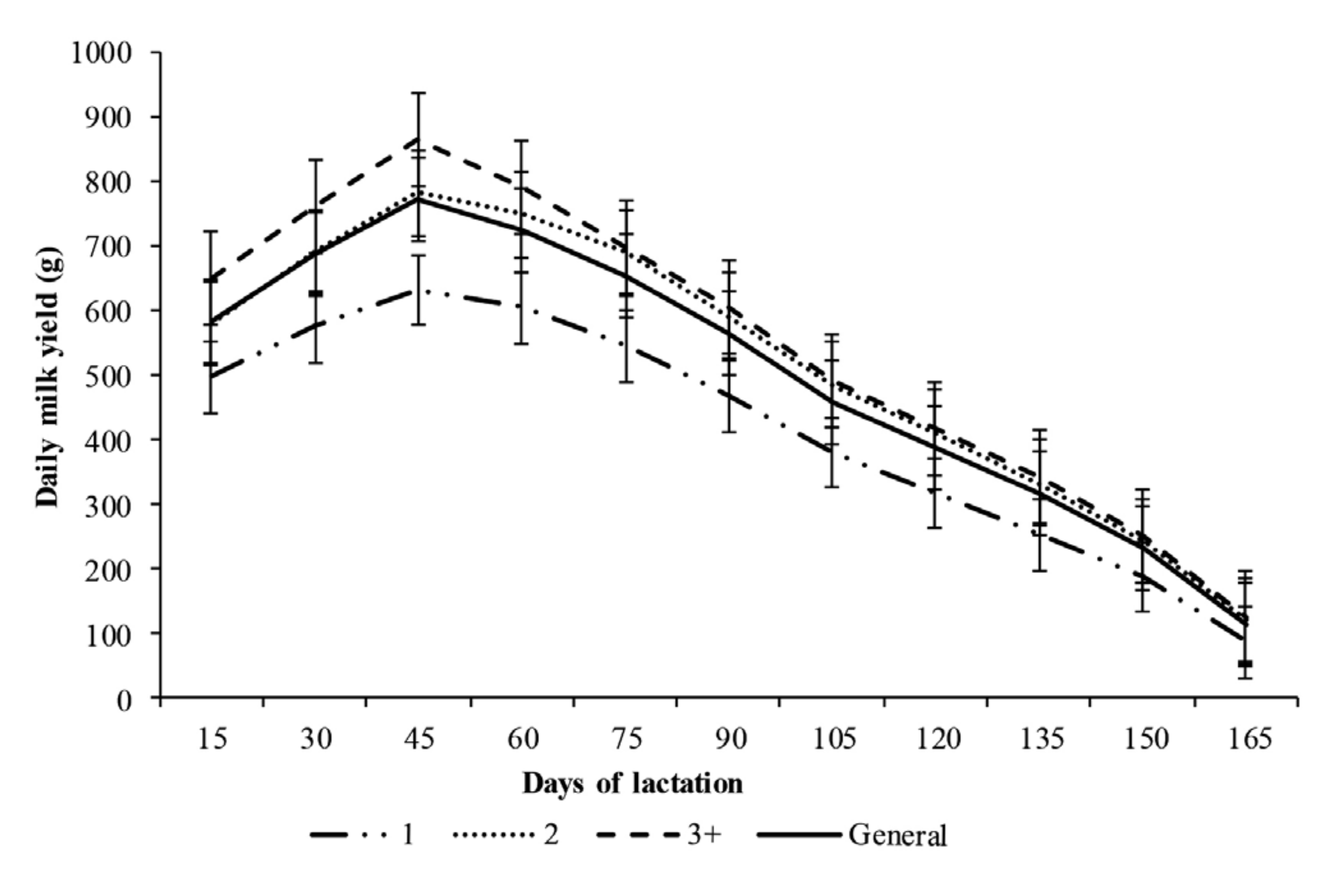

Figure 2 - Lactation curves for various lactation numbers.

Table 3 - Least squares means (±SE) of some milk quality characteristics.

Items	Traits			
	pH	Color		
		L*	a*	b*
LN				
1	6.55±0.01	91.29±0.36	-4.38±0.07	7.84±0.15
2	6.51±0.02	90.97±0.35	-4.40±0.06	7.41±0.15
3+	6.53±0.01	90.43±0.35	-4.42±0.07	7.37±0.14
P	0.153	0.224	0.928	0.053
LS				
Early	6.51±0.01a	91.10±0.33	-4.61±0.06a	7.71±0.14
Middle	6.59±0.02b	90.55±0.35	-4.58±0.06a	7.27±0.15
Late	6.49±0.02a	91.04±0.38	-4.01±0.07b	7.65±0.16
P	<0.001	0.465	<0.001	0.072
MT				
Morning	6.51±0.01	90.77±0.29	-4.67±0.06	6.60±0.12
Evening	6.55±0.01	91.02±0.29	-4.12±0.06	8.49±0.12
P	0.004	0.538	<0.001	<0.001
Interactions				
LNxLS	0.300	0.588	0.203	0.083
LNxMT	0.820	0.363	0.826	0.079
LSxMT	0.337	0.231	0.017	0.428
LNxLSxMT	0.946	0.799	0.614	0.301
TOTAL	6.53±0.01	90.90±0.22	-4.40±0.04	7.54±0.09

Means with unlike letters in columns (a, b) differ significantly (P<0.05). LN Lactation number, LS Lactation stage, MT Milking time.

Table 4 - Means (±SE) of fatty acid composition (in percent).

Fatty Acids	LN				LS				Interaction	TOTAL
	1	2	3+	P	Early	Middle	Late	P	LNxLS	
C4:0	0.220±0.044	0.216±0.043	0.290±0.040	0.371	0.277±0.039	0.185±0.042	0.263±0.046	0.243	0.207	0.242±0.025
C6:0	0.732±0.029	0.712±0.029	0.700±.027	0.720	0.888±0.026a	0.646±0.028b	0.611±0.031b	<0.001	0.230	0.715±0.016
C 8:0	1.724±0.087	1.616±0.084	1.691±0.079	0.656	2.055±0.077a	1.576±0.082b	1.401±0.091b	<0.001	0.571	1.677±0.048
C10:0	8.938±0.300	9.113±0.292	9.335±0.275	0.619	10.680±0.268a	8.677±0.283b	8.031±0.315b	<0.001	0.508	9.129±0.167
C12:0	4.600±0.201	4.713±0.196	5.069±0.184	0.200	5.529±0.180a	4.111±0.190b	4.741±0.211b	<0.001	0.738	4.794±0.112
C14:0	9.484±0.250	9.803±0.243	10.326±0.229	0.047	9.598±0.223	9.857±0.235	10.157±0.262	0.273	0.893	9.871±0.139
C14:1	0.286±0.020	0.331±0.019	0.293±0.018	0.232	0.301±0.018	0.311±0.019	0.298±0.021	0.884	0.407	0.304±0.011
C15:0	1.129±0.037	1.140±0.036	1.059±0.034	0.211	1.188±0.033a	1.199±0.035a	0.941±0.039b	<0.001	0.316	1.109±0.021
C15:1	0.203±0.010	0.198±0.010	0.219±0.009	0.266	0.222±0.009a	0.227±0.010a	0.171±0.011b	<0.001	0.359	0.207±0.006
C16:0	28.114±0.551	27.486±0.536	28.469±0.505	0.411	23.846±0.492a	28.551±0.520b	31.672±0.579c	<0.001	0.996	28.023±0.307
C16:1	0.935±0.043ab	0.985±0.041b	0.834±0.039b	0.030	1.044±0.038a	0.813±0.040b	0.897±0.045b	<0.001	0.792	0.918±0.024
C17:0	0.820±0.021	0.799±0.020	0.772±0.019	0.233	0.773±0.018a	0.910±0.019b	0.706±.022a	<0.001	0.707	0.797±0.011
C17:1	0.254±0.010ab	0.272±0.009a	0.231±0.009b	0.009	0.281±0.009a	0.252±0.009ab	0.223±0.010b	<0.001	0.781	0.252±0.005
C18:0	14.646±0.638	13.911±0.621	13.694±0.585	0.528	13.089±0.570a	16.436±0.602b	12.725±0.670a	<0.001	0.956	14.083±0.355
C18:1	22.426±0.636	23.329±0.619	22.175±0.583	0.375	24.048±0.567a	21.014±0.600b	22.868±0.667ab	0.002	0.214	22.643±0.354
C18:2 ω6	2.800±0.102	2.851±0.099	2.657±0.094	0.338	3.148±0.091a	2.592±0.096b	2.570±0.107b	<0.001	0.854	2.770±0.057
C18:3 ω3	1.060±0.042	1.058±0.041	1.060±0.038	0.999	1.209±0.037a	1.143±0.039a	0.825±0.044b	<0.001	0.608	1.059±0.023
C18:3 ω6	0.994±0.057	0.948±0.056	0.850±.053	0.170	1.529±0.051a	0.745±0.054b	0.517±0.060c	<0.001	0.873	0.931±0.032
C20:0	0.365±0.017	0.365±0.017	0.350±.016	0.750	0.336±0.015a	0.412±0.016b	0.331±0.018a	0.001	0.997	0.360±0.009
C20:1	0.136±0.009	0.128±0.009	0.134±.008	0.806	0.139±0.008ab	0.149±0.009a	0.110±0.010b	0.012	0.895	0.132±0.005
C22:0	0.158±0.007	0.152±0.006	0.152±0.006	0.795	0.138±0.006a	0.203±0.006b	0.122±0.007a	<0.001	0.749	0.154±0.004

Means with unlike letters in lines (a, b, c) differ significantly (P<0.05). LN Lactation number, LS Lactation stage.

(P<0.01), and MT (P<0.001), SCC was similar for LN, but different for LS (P<0.001) and MT (P<0.001). The differences of percentages among milk protein (P<0.01) and dry matter (P<0.01) for LN groups were significant. In addition, percentages for protein, lactose, and dry matter were influenced significantly by LS and MT (P<0.05, P<0.001). The interactions among factors for milk composition and SCC were generally found to be insignificant.

Table 3 shows the pH and color coordinates means of the milk obtained from the goats with different LN and LS. The pH values generally differed significantly for LS (P<0.001) and MT (P<0.01), and it was measured between 6.49 and 6.59. The effects of LN on the color coordinates were not significant, however the effects of LS on a*, and MT on a* and b* were highly prominent (P<0.001). The interactions among factors for pH and color coordinates were not generally significant.

The milk fatty acid composition, and sums and indexes based on fatty acids were presented in Tables 4 and 5, and they varied significantly (P<0.01, P<0.001) because of LS, with some exceptions for C4:0, C14:0, and C14:1. Major fatty acids in milk were palmitic (C16:0) (28.023%), oleic (C18:1) (22.643%), and stearic (C18:0) (14.083%) acids during the entire lactation period.

DISCUSSION

The main systems of goat farming are pasture-rangeland and indoor systems, or mixed systems of them, such as summer pasture-rangeland/winter indoors or indoors/outdoors due to climate. The systems based on pasture-rangeland may vary subject to agro-climatic and socio-ecologic conditions of the regions. Considering the systems based on grazing and indoor systems, these systems affect both level of milk production and the milk components (fat, protein, lactose, fatty acids), especially in milk production[7].

In the current study, daily milk yield was increased due to LN, and this may be due to higher feed intake of the older goats and well-developed udder tissue and gastrointestinal system compared to the young goats. It is noteworthy that there was a wide variation of daily milk yield in the flock where this research was conducted. It was determined that the goats yielded half the lactation milk yield in the one-third of the lactation period and the other half of the lactation milk yield in the last two-thirds of the lactation period. As can be seen from the Figure 2, it was found remarkable that the shapes of lactation curves for different LN groups were similar to the typical shapes of lactation curves, except for shorter lactation duration, obtained for dairy goats[8,13].

In this study, the lactation milk yield (87.47 kg) and lactation period (178.14 days) were found to be significantly higher than the values (35 kg and 120 days) reported as breed characteristics for Angora goat[2], however similar to the findings (88.2 kg and 179.3 days) ascertained for the same breed in semi-intensive conditions[3]. These results support that Angora goats could also benefit for milk yield.

LN, LS, and MT caused a significant change in milk fat content. The LN 1 goats had a higher milk fat content than those of the other LN goats. At the same time, the milk yield of LN 1 goats was lower than those of the others (Table 1). It has been well documented that fat content is negatively correlated with milk yield[4,8,13], and increase milk yield decrease fat content by

Table 5 - Sums and indexes based on fatty acids.

Items	LN				LS				Interaction	TOTAL
	1	2	3+	P	Early	Middle	Late	P	LNxLS	
SFA	70.929±0.657	70.027±0.639	71.906±0.602	0.109	68.398±0.586a	72.764±0.619b	71.701±0.689b	<0.001	0.284	70.954±0.365
MUFA	24.241±0.630	25.242±0.613	23.886±0.577	0.262	26.035±0.562a	22.766±0.594b	24.568±0.661ab	<0.001	0.232	24.456±0.351
PUFA	4.854±0.141	4.857±0.138	4.567±0.130	0.216	5.886±0.126a	4.480±0.133b	3.911±0.148c	<0.001	0.909	4.759±0.079
UFA	29.095±0.652	30.099±0.634	28.453±0.597	0.174	31.922±0.582a	27.246±0.615b	28.479±0.684b	<0.001	0.344	29.216±0.363
DFA	43.741±0.922	44.010±0.898	42.147±0.845	0.266	45.011±0.823a	43.683±0.870ab	41.204±0.968b	0.015	0.753	43.299±0.513
MUFA/SFA	0.348±0.011	0.361±0.011	0.333±0.010	0.166	0.382±0.010a	0.317±0.010b	0.345±0.011b	<0.001	0.255	0.348±0.006
PUFA/SFA	0.069±0.002	0.070±0.002	0.064±0.002	0.114	0.086±0.002a	0.062±0.002b	0.055±0.002b	<0.001	0,985	0.068±0.001
UFA/SFA	0.417±0.012	0.431±0.012	0.397±0.011	0.112	0.468±0.011a	0.378±0.011b	0.400±0.013b	<0.001	0.355	0.415±0.007
ω6	3.795±0.128	3.799±0.124	3.507±0.117	0.153	4.677±0.114a	3.337±0.121b	3.087±0.134b	<0.001	0.967	3.700±0.071
ω3	1.060±0.042	1.058±0.041	1.060±0.038	0.999	1.209±0.037a	1.143±0.039a	0.825±0.044b	<0.001	0.608	1.059±0.023
ω6/ω3	3.698±0.167	3.733±0.163	3.388±0.153	0.240	3.962±0.149a	3.002±0.158b	3.854±0.176a	<0.001	0.785	3.606±0.093
NV	1.363±0.049	1.383±0.047	1.297±0.045	0.389	1.562±0.044a	1.336±0.046b	1.145±0.051c	<0.001	0.865	1.348±0.027
AI	2.132±0.116	1.932±0.112	2.137±0.106	0.338	1.797±0.103a	2.330±0.109b	2.075±0.121ab	0.003	0.283	2.067±0.064
TI	1.975±0.112	1.740±0.109	1.888±0.102	0.314	1.494±0.100a	2.136±0.105b	1.974±0.117b	0.001	0.382	1.868±0.062

Means with unlike letters in lines (a, b, c) differ significantly (P<0.05). LN Lactation number, LS Lactation stage, SFA Saturated fatty acids, MUFA Monounsaturated fatty acids, PUFA Polyunsaturated fatty acids, UFA Total unsaturated fatty acids, DFA Desirable fatty acids (C18:0 + UFA), NV (Nutritive value) (C18:0 + 18:1) / C16:0, ω6/ω3 (C18:2ω6 + C18:3ω6) / C18:3ω3, AI Atherogenic index, TI Thrombogenic index.

dilution[7]. Karadağ et al.[14] who studied the milk yield of Saanen crossbreds reported that the fat content of the milk decreased as LN rose (3.22, 3.07, 2.96, and 2.89% for LN 1, 2, 3, and 4+, respectively). Morand-Fehr et al.[7] underlined that pasture or rangeland based farming systems result in milk performance characterized by high-fat content due to diets rich in fibre.

The effects of LN, LS, and MT on milk protein percentage were prominent; protein contents were found to be highest in the early lactation stage (4.26%), decreased in the middle (3.96%) and the last (4.05%) stages while the evening milk had approximately 0.20% higher protein than the morning milk. The changes for milk protein percentage according to the LS were ascertained from the studies carried out on Damascus goats[8,15]. The higher protein content of evening milk in the current study was similar to the results of Turkish Saanen goats[13].

The milk lactose percentage was influenced significantly by the LS and MT. Similar to the Damascus Cyprus goats[16], the milk lactose percentage in the late lactation stage was lower than those of the other lactation stages; however, in contrast to the study on Turkish Saanen Goats[13], the lactose percentage of morning milk (5.09%) was higher than the that of evening milk (4.87%). The dry matter percentages in the milk obtained between 13.58-16.48% were higher than the results of dairy goat breeds[16,17] but similar to indigenous hair goat breed[18].

As reported by Goetsch et al.[19], there were great differences for SCC among goat breeds, and it usually between 2×10^5 and 10×10^5 mL. The SCC was changed significantly according to LS and MT. Much lower SCC compared to findings of the studies[8,17,19] could be a result of all the goats in this study in which had never been used as dairy goat, as stated before. The SCC values of Angora goats in the present study were acceptable because of assuming that an SCC value greater than $1\text{x}10^6$/ml was regarded as undesirable[17].

pH is a very essential parameter for ascertaining milk quality as it converts milk to cheese via coagulation of proteins. pH values in the present trial, measured between 6.49 to 6.59, were compatible with the findings of Pizzillo et al.[20] for Garganica and Siriana goats. It is well understood that the milk color affects the color properties of the subsequent dairy products. It has been observed that as the LN increased the milk L* (lightness index) tend to decrease, although the differences were insignificant. The milk lightness is related to many natural pigmentations, including mainly fat globules[21]. LS had significant effects on a* (redness index) because of decreasing a* values as lactation progress. The b* (yellowness index) values did not differ significantly in LN and LS, but significantly in MT. The b* value in milk is closely related to fat content and level of β-carotene; a greater milk fat content results in increasing the b* index[21]. Feeding types of goats may be altered fat content, thus b* value of milk. An increase in the b* value in evening milk might be explained by the rising content of fat in evening milk.

The fatty acid composition of goat milk is one of the important parameters of milk quality, especially the effect on human nutrition. The fatty acid profile and contents in milk influence the quality, texture, aroma, and flavor of milk and milk products[22]. Twenty-one fatty acids in the current trial were detected from butyric acid (C4:0) to behenic acid (C22:0), and the effect of LS on fatty acid composition was generally found to be important. Caproic (C6:0), Caprylic (C8:0), and Capric (C10:0) acids, which are among the medium-chain fatty acids, have a great role in the specific odor of goat milk[4]. A significant decrease in these fatty acids from the early lactation stage to the late lactation stage may indicate that the specific odor of goat milk reduces towards the end of lactation.

The primary saturated fatty acids (SFA) identified from the milk fat were palmitic acid (C16:0) and stearic acid (C18:0), while oleic acid (C18:1) was the main monounsaturated fatty acid (MUFA). Palmitic acid, which is important because of nutritive value, was significantly increased with lactation progress, in accordance with the reports of Damascus goats[8]. Stearic acid, which is one of the desirable fatty acids, showed a significant increase from early to middle lactation stage (13.089% to 16.436) but decreased (12.725%) in the late lactation stage, similar to the early lactation stage. This situation was different from the results for Damascus goats by Yakan et al.[8]. Due to the importance of the SFA and UFA values for evaluating fatty acid composition in milk, high SFA and low UFA are not desirable because of human health. It was found that SFA increased, and UFA decreased in the middle and late stages of lactation compared to the early stages of lactation. While the average values of SFA and UFA during entire lactation in this trial were in line with those described by Goetsch et al.[19], the changing for SFA rising and UFA decreasing during lactation was noteworthy. The overall ratio between ω6 and ω3 PUFA (3.606), one of indexes used to assess the nutritional value of fats, should not exceed 4.0[12], were under the recommendation level in the present study. This was dissimilar to the results with higher ratios for ω6/ω3 in Damascus goats which were fed with concentrate and pasture (6.01 and 6.75)[8], and in Saanen and Swedish Landrace goats which were fed with mainly concentrate diet (6.05 and 6.33)[22]. In this study, the low ratio of ω6/ω3 may be related to the feeding of goats based on rangeland, in fact, it was reported that feeding on rangeland increased ω3 in milk[4]. Considering nutritive value (NV) and atherogenic index (AI) and thrombogenic index (TI), the other indexes used to assess the nutritional value of fats, NV decreased during entire lactation, AI and TI values increased in the middle lactation stage and then decreased partially. However, it was noted that both AI and TI values found in the current study were above the desired value of 1 throughout the lactation period[12]. The lower the AI value, the better for human nutrition.

CONCLUSIONS

The study displayed the milk yield and lactation period of Angora goats based on rangeland feeding conditions was higher than the averages accepted for the breed. It has been determined that Angora goats had acceptable values for milk composition and quality characteristics. Fatty acid compositions varied throughout the lactation period, SFA increased, and UFA decreased, and indexes of nutritional values partially decreased at the late stage of lactation.

ACKNOWLEDGEMENTS

This study was prepared from senior author PhD thesis.

Bibliografia

1. Anonymous (2020). Turkish Statistical Institute, Livestock Statistics, http://www.turkstat.gov.tr, Turkey.
2. Yalçın B.C. (1986). Sheep and Goats in Turkey. FAO Animal Production and Health Paper, Rome.
3. Erol H., Akçadağ H.I., Ünal N., Akçapınar H. (2012). Milk yield and its effect on kids growth in Angora goats. Ankara Univ Vet Fak Derg, 59: 129-134.
4. Park Y.W., Haenlein G.F.W. (2010). Milk Production. In: Goat Science and Production, Ed. Solaiman S.G., 1st Ed., 275-292, Wiley-Blackwell, New York.
5. Sahlu T., Carneiro H., El Shaer H., Fernandez J., Hart S., Goetsch A. (1999). Dietary protein effects on and the relationship between milk production and mohair growth in Angora does. Small Rum Res, 33: 25-36.
6. McGregor B.A. (2018). The effects of nutrition and parity on the development and productivity of Angora goats: 3. Effects of six combinations of mid pregnancy and postnatal nutrition on udder development, lactation, milk composition and net energy of milk production. Small Rum Res, 161: 13-23.
7. Morand-Fehr P., Fedele V., Decandia M., Le Frileux Y. (2007). Influence of farming and feeding systems on composition and quality of goat and sheep milk. Small Rum Res, 68: 20-34.
8. Yakan A., Özkan H., Eraslan Sakar A., Ates C.T., Ünal N., Koçak Ö., Doğruer G., Özbeyaz C. (2019). Milk yield and quality traits in different lactation stages of Damascus goats: concentrate and pasture based feeding systems. Ankara Univ Vet Fak Derg, 66: 117-129.
9. Kendir H. (1999). Vegetation composition, forage yield and range condition of a natural rangeland in Ayas (Ankara). Tarım Bil Derg, 5: 104-110.
10. Maria G., Gabina D. (1992). Simplification of milk recording scheme in Latxa milking sheep. Livest Prod Sci, 31: 313-320.
11. CIELAB (1976). CIELAB Colour System, Commission International de l'Eclairage, Paris, France.
12. Ulbricht T.L.V., Southgate D.A.T. (1991). Coronary heart disease: seven dietary factors. Lancet, 338: 985-992.
13. Tölü C., Irmak S., Açıkel Ş., Akbağ H., Savaş T. (2016). Comparison of milk yield, milk composition and residual milk of machine and hand-milked in Turkish Saanen Goats. Tarım Bil Derg, 22: 462-470.
14. Karadağ O., Yılmaz M., Yıldırım M., Yüksel M.A., Sezenler T. (2012). Saanen, G_1 ve G_2 keçilerinde üreme, süt verimi ve besi özellikleri üzerinde kar ıla tırmalı ara tırmalar. Gıda, Tarım ve Hayvancılık Bakanlığı Tarımsal Araştırmalar ve Politikalar Genel Müdürlüğü, Büyükbaş ve Küçükbaş Hayvancılık Araştırmaları Program Değerlendirme Toplantısı, 139-153, Antalya.
15. Mahmoud N.M.A., El Zubeir I.E.M., Fadlelmoula A.A. (2014). Effect of stage of lactation on milk yield and composition of first kidder Damascus does in the Sudan. J Anim Prod Adv, 4: 355-362.
16. Rawya A.A.S., Ahmed K.A. (2014). Physicochemical characteristics of Damascus (Shami) Cyprus goats milk in different lactation periods. IJLASS, 2: 67-72.
17. Paape M.J., Wiggans G.R., Bannerman D.D., Thomas D.L., Sanders A.H., Contreras A., Moromi P., Miller R.H. (2007). Monitoring goat and sheep milk somatic cell counts. Small Rum Res, 68: 114-125.
18. Balia F., Pazzola M., Dettori M.L., Mura M.C., Luridiana S., Carcangiu V., Piras G., Vacca G.M. (2013). Effect of CSN1S1 gene polymorphism and stage of lactation on milk yield and composition of extensively reared goats. J Dairy Res, 80: 129-137.
19. Goetsch A.L., Zeng S.S., Gipson T.A. (2011). Factors affecting goat milk production and quality. Small Rum Res, 101: 55-63.
20. Pizzillo M., Claps S., Cifuni G.F., Fedele V., Rubino R. (2005). Effect of goat breed on the sensory, chemical and nutritional characteristics of ricotta cheese. Livest Prod Sci, 94: 33-40.
21. McDermott A., Visentin G., McParland S., Berry D.P., Fenelon M.A., De Marchi M. (2016). Effectiveness of mid-infrared spectroscopy to predict the color of bovine milk and the relationship between milk color and traditional milk quality traits. J Dairy Sci, 99 (5): 3267-3273.
22. Yurchenko S., Sats A., Tatar V., Kaart T., Mootse H., Joudu I. (2018). Fatty acid profile of milk from Saanen and Swedish Landrace goats. Food Chemist, 254: 326-332.