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The effect of different management systems on milk yield and milk quality in Awassi sheep

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Abstract. This study aimed to evaluate the effect of concentrate-based feeding (CF) and artificial pasture-based grazing (APG) management systems on milk yield, fatty acids, nutritional indices, and milk physicochemical characteristics of Awassi ewes. The research involved 300 heads of Awassi ewes, which were divided into two groups. Awassi sheep were managed in a CF and APG system to test the milk yield characteristics. The results showed a significant ($P < 0.01$) difference in milk yield and lactation length between CF and APG management systems of ewes. The average daily milk yield showed a nonsignificant difference for both management systems, and no significant changes ($P > 0.05$) in the chemical composition of CF and APG management systems were observed. Palmitic (C16:0), myristic (C14:0), stearic (C18:0) capric (C10:0), and lauric (C12:0) acids were the major saturated fatty acids found in milk from both management systems. The level of linoleic acid (C18:2 n-6) was significantly different in both treatments ($P < 0.05$), but the linolenic (C18:3 n-3) acid level was nonsignificant in milk from the CF and APG management systems. The hypocholesterolemic / hypercholesterolemic (h / H) fatty acid and thrombogenicity (TI) ratios were significantly different ($P < 0.05$); however, the atherogenicity (AI) had no significant difference between confined and grazing systems. In conclusion, it can be said that the lactation length and lactation milk yield were prolonged by the APG management system, though the milk composition and quality were not significantly affected.

1   Introduction

Sheep production has a significant economic impact on the rural areas across Turkey, there are 45 177 690 heads of dual-purpose ewes, and they produce approximately 1 143 762 tons of milk (4.92 %) annually (TURSTAT, 2022). The major proportion of sheep milk is converted into high-value products like yogurt, butter, Ezine and Divle Obruk cheeses, and different types of Tulum, Van Otlu, and Mihaliç cheeses. Therefore, knowledge of the chemical composition, physicochemical properties, and nutritional value of sheep's milk is important. The quality and quantity of milk produced by farmers can be increased by providing a better management

system, improved genetics, a hygienic environment, and better pasture conditions for grazing.

The dairy industry and consumers prefer high-quality milk. Moreover, in recent years, there has been an increasing interest of consumers in sheep and goat milk and products in terms of nature, nutrition, and health. The production of high-quality dairy products for the dairy industry is only possible by increasing the quality and quantity of milk. The quality of sheep milk is affected by genetic (breed) and environmental factors such as feeding, rearing system, milking method, and season. Sobrino et al. (2018) reported that milk quality evaluation is important not only for cheese production, but also for other dairy products. The composition and physicochemical

characteristics of goat and sheep milk are essential for the successful development of the dairy goat and sheep industries as well as for the marketing of the products (Park et al., 2007). The chemical composition and physicochemical properties of the milk determine the quality of yogurt, cheese, and other products. The properties of milk depend on numerous factors. The lactation stage, nutrition, farm conditions, and all meteorological factors affect the milk yield, composition, and quality of milk (Kuchtik et al., 2017; Gonzalez-Ronquillo et al., 2021). The farming system in which sheep are raised can affect the milk properties depending on the intensive or semi-intensive production system. It is established that grazing can improve the fatty acid composition of milk (Kasapidou et al., 2021). Therefore, pasture-based feeding strategies could improve the fatty acid composition and the nutritional properties of sheep dairy products. However, it is believed that adequate and balanced fat consumption is necessary, and therefore fatty acids should be part of the diet in a proper ratio to provide the contents required by the body. Moreover, dietary fats can play positive or negative roles in the prevention and treatment of diseases (Chen and Liu 2020). The milk fatty acid composition and nutritional value were significantly improved in milk from farms using the semi-intensive production system, and this favorable effect was attributed to the inclusion of pasture in the sheep's diet. In nature, fatty acids occur in the form of mixtures of saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs), and polyunsaturated fatty acids (PUFAs), so their nutritional and/or medicinal values must be determined. Furthermore, the fatty acid composition in the milk is highly influenced by external factors, including animal nutrition, farming management, and pasture composition.

The objective of this study was to evaluate the milk yield, chemical composition, physicochemical properties, fatty acid composition, and nutritional value of Awassi sheep milk produced in different management systems.

2　Materials and methods

2.1　Location

The study was carried out on a private dairy sheep farm located in the Central Anatolia region, Turkey (37°50′14.2″ N, 34°10′39.0″ E; altitude of approximately 1086 m) in the period from late March to late October 2021.

2.2　Animal feeding and management

Lambs were kept in cages with their mothers for the first 5 d after lambing. After the first week, lamb starter feed and alfalfa rough were given to the lamb ad libitum. Lambs were weaned at approximately 45 d of age. The milk control interval was determined to be 30 d. Ewes were dried off when milk yield decreased below 100 mL.

In this experiment, 300 heads of ewes between the ages of 2 and 6 were selected from 2000 heads of sheep that gave birth in the same month and were divided into two groups: concentrate-based feeding (CF) and artificial pasture-based grazing (APG). The first group of animals was kept in permanent housing with no access to artificial pasture and was fed with a total mixed ratio (TMR) consisting of $0.965\,\mathrm{kg\,d^{-1}}$ maize silage, $0.09\,\mathrm{kg\,d^{-1}}$ wheat straw, $1.3\,\mathrm{kg\,d^{-1}}$ concentrate, and $1.35\,\mathrm{kg\,d^{-1}}$ alfalfa (during lactation). The CF group's ewes were fed with concentrated (30.2 % barley, 10.6 % soybean meal, 17 % cottonseed meal, 6 % sunflower meal, 33.9 % corn, 1.5 % mineral, vitamins, and 0.8 % salt) milk feed containing 16.1 % protein and 2796 kcal per metabolizable energy (ME) per kilogram twice a day. The CF animals were fed diets that were formulated according to the NRC (2007).

The ewes in the APG group did not have any additional feeding; however, they were grazed for at least 8 h of the day on artificial pastures which had separate electric fences. The pasture area, which was established as approximately 30 ha in 2019, was divided equally into six parcels of 5 ha with electric fences. The grazing process for ewes was started when the plant height of the species in the pasture reached approximately 15–20 cm. The samples taken from the wire cages and placed in the pasture plots just before grazing with the sheep were divided by species, and it was determined that the botanic composition in the grazing season consisted of 85 % of grasses and 15 % of legumes. The stocking rate was 24 ewes $\mathrm{ha^{-1}}$ (0.5 ha per paddock). The quality analyses of the samples were made with the NIRS (near-infrared reflectance spectroscopy) analyzer (Shenk and Westerhaus, 1994). The crude protein is between 14.4 % *grass* and 19.0 % *legumes* and acid detergent fiber (ADF) and neutral detergent fiber (NDF) content between 32.0 % and 35.8 % for *grass* and between 61.8 % and 45.7 % for *legumes* on a dry matter basis, depending on the grazing pressure exerted by each treatment. In the spring, summer, and fall seasons, fresh herbage and dry herbage yields were calculated on average to be 804 and 285 kg $\mathrm{ha^{-1}}$, respectively (Fig. 1).

2.3　Soil preparation, pasture establishment, and forage quality

An area of 30 ha, which was previously used for growing field crops, was planned for an artificial pasture establishment to be grazed with sheep. The pasture was set up with a mixture of six different perennial species, including perennial ryegrass (*Lolium perenne* L.), smooth bromegrass (*Bromus inermis*), and tall fescue (*Festuca arundinacea Schreb*), grasses and three legume species, white clover (*Trifolium repens* L.), alfalfa (*Medicago sativa* L.), and sainfoin (*Onobrychis sativa*), as legumes that were previously adapted to the region. Germination tests of the seeds of the species were carried out before sowing. Seeding rates were 10, 10, 8, 3, 1, and 10 kg $\mathrm{ha^{-1}}$ for perennial ryegrass, tall fescue, smooth

Figure 1. Sample collection from pasture.

bromegrass, alfalfa, white clover, and sainfoin, respectively. The seed bed was prepared by ploughing and then firming with a field cultivator and harrow. After the seeds were thoroughly mixed on a tarpaulin at the specified rates, sowing was conducted by a universal type of seeder by adjusting to $30 \, \text{kg ha}^{-1}$-mix seeds. During the sowing, 30 kg of diammonium phosphate (DAP) fertilizer was used per hectare with a seeder. The pasture was sown in the first week of October 2019.

2.4 Lactation milk yield and length

The CF and APG ewes were milked twice a day with an automatic milking system, and milk yields were obtained from the system at the end of lactation. The lambs suckled their mothers for 45 d, and then the sheep were milked. During this period, the lambs were separated 12 h before the milk control from their mothers, and ewes were directed to milking. The Fleishmann method was used to obtain the lactation milk yield for each ewe (Barillet et al., 1992). Lactation length was calculated as the date of dry-off and time of birth.

2.5 Milk chemical composition and somatic cell count

Milk samples of ewes from CF and APG ewes were collected individually during milking in 50 mL plastic screw-capped flasks, placed in isothermal containers with ice packs, and transported to the laboratory. For the chemical analysis of milk, a total of 150 individual samples was taken from the sheep once in the middle of lactation (early June) with a milk collection container mounted on the milking system. Milk composition (fat, protein, lactose, and total solid content) was determined by infrared analysis (FTIR interferometer) using a Milkana® Express Plus Analyzer. Somatic cell count (SCC) was determined with a Milkana® Somatic Scan Analyzer, and the obtained data were log-transformed to normal-

ize the distribution. A pH meter equipped with a penetrating electrode and a thermometer (Hanna Instruments, HI–9025) was used to determine pH immediately after milking. It was calibrated with standard buffer solutions at pH 4.0 and 7.0 according to the manufacturer's instructions.

2.6 Milk fatty acid composition

For the analysis of milk fatty acids, a total of 50 ewes' milk samples were collected in early June and kept at $-20 \, °\text{C}$ until analysis. The fatty acid composition was determined by gas chromatography (GC) as described by Papaloukas et al. (2016). Fatty acids were quantified by the peak area measurement, and the results were expressed as the percent (%) of the total peak areas for all quantified acids. Fatty acids were grouped as SFAs, MUFAs, PUFAs, and unsaturated fatty acids (UFAs).

2.7 Milk lipid quality nutritional indices

The milk fatty acid profile was used to calculate the following indices related to healthy fat consumption. In addition, all nutritional indices were used to assess the nutritional value of milk and other dairy products in various studies. The hypocholesterolemic / hypercholesterolemic fatty acid ratio (h / H) ratio was calculated according to the formula reported by Chen and Liu (2020). The atherogenicity (AI) and thrombogenicity (TI) indices were calculated according to the following formulae offered by Ulbricht and Southgate (1991). The health-promoting index (HPI) was recommended by Chen et al. (2004).

2.8 Statistical analysis

Statistical analysis was performed using a one-way analysis of variance (ANOVA) with SPSS software package release 22.0 (SPSS, 2016). An analysis of variance was carried out

considering the production system to have fixed effects. The results were significant when the P values were <0.05.

3 Results and discussion

3.1 Milk production characteristics

Awassi sheep were managed on CF and APG production systems to compare the milk yield. The lactation curves for the management systems are presented in Fig. 1, and the mean values of milk yield and lactation length of the Awassi ewes are shown in Table 1. The results obtained after feeding showed that there was a significant ($P<0.001$) difference in milk yield and lactation length between the CF and APG groups, but the average daily milk yield showed non-significant differences for both management systems. The milk yields for CF and APG were 167.68 and 204.61 L, respectively, and the lactation lengths for CF and APG ewes were 205.05 and 232.72 d. The daily average milk yields for CF and APG ewes were 0.816 and 0.878 L, respectively. The lactation length and milk yield showed a significant difference when compared to the production system. Basdagianni et al. (2019) showed similar results after comparing the spring lambing and fall lambing raised on semi-extensive production systems for the Chios sheep breed, with a lactation length of 208 d and a milk yield of 324 kg. De Renobales et al. (2012) reported high milk yields in all grazing groups of sheep in the control group; their result proved that grazing sheep when supplemented with concentrate can improve milk yield over non-grazed animals. Daş et al. (2022) found a significant difference between age groups 105, 120, 135, and 150 d for milk yield, and they also found a significant difference in added milk yield on days 165 and 180 of lactation. Lactation milk yield and lactation period in Awassi sheep were calculated to be 168.10 ± 8.44 kg and 166.10 ± 2.11 d, respectively. While this result was similar to the CF group (167.68 L), it was found to be lower than that of the APG sheep (204.61 L and 232.72 d). Similarly, in Kutan and Keskin (2022), the average marketable milk yield in Awassi sheep is 76.6 L, which is lower than our findings. Grazing the sheep on sulla grass improved the milk yield over the milk yield of other ewe groups (Bonanno et al., 2016). Yakan et al. (2019) reported a higher milk yield in the pasture-based feeding group than in the concentrate-based feeding group.

The abovementioned studies' results are in agreement with our results: the animals managed on grazing have their milk yield and lactation length significantly improved over the non-grazed intensively managed animals.

3.2 Milk chemical and physicochemical composition

Table 2 shows the means of milk chemical composition and some milk quality parameters. Milk from the CF and APG ewes had no significant difference ($P>0.05$) in fat, lactose, and fat / protein rate (Table 2). However, the protein rate in
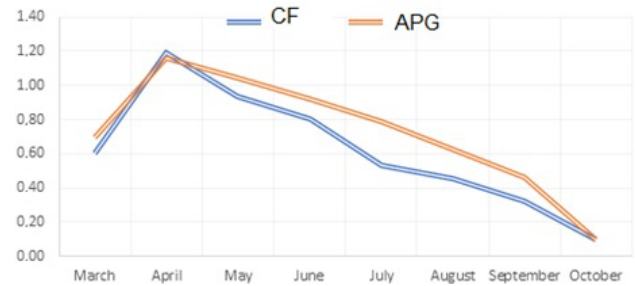
Figure 2. Lactation curves of the ewes' different management systems.

the milk of animals kept on the APG was higher than those kept in the CF, and the difference between the groups was statistically significant ($P<0.05$).

Electrical conductivity (EC), milk somatic cell count, and pH of milk did not differ significantly ($P>0.05$) among the two management systems, as expected (Table 2). The physicochemical properties of milk were affected by the chemical composition of milk and the number of somatic cells. There can be a relationship between the electrical conductivity of milk and the occurrence of mastitis. The protein percentage is significantly higher in the APG group, showing that grazing affects the protein percentage as compared to confined animals.

Kuleile et al. (2021) studied the performance of lactating ewes in four groups: control group, T1 forage only, T2 forage with concentrate, and T3 forage with urea molasses and concentrate. The T1 group showed better milk than the other groups, and the T3 group showed better amounts of milk protein, density, and solids not fact (SNF) than the control group and T2. Obeidat et al. (2019) reported similar results saying that the animals with supplementation showed better levels of SNF, protein, and milk butter fat than the control group. The T1 group fed only on forage showed the lowest level of milk fat percentage. The dietary treatment of the T3 group with concentrated urea molasses had an effect on milk which caused higher levels of milk protein, density, SNF, and lactose content. These results suggest that if the animals are supplemented with high nutrients along with forage food, the milk composition of ewe's milk will be further improved. However, our study did not show any significant difference in milk composition, which indicates that the addition of supplementing high-nutrient feed along with grazing can provide increased protein, SNF, and butter fat. Daş et al. (2022) Awassi sheep overall mean fat, protein, and lactose ratios were determined to be 6.27 ± 0.10 %, 5.12 ± 0.05 %, and 4.81 ± 0.05 %, respectively. The milk fat and protein ratios obtained in our study were higher than these findings, except for the lactose ratio. SCC is widely used for evaluating milk quality. An increased SCC results either from an inflammatory process due to the presence of an intramammary infection or, under non-pathological con-

Table 1. Milk yield and lactation length of the Awassi ewes of the different management systems.

Variables	Management systems			
	CF ($n = 150$)	APG ($n = 150$)	SEM	P value
MY, liter	167.68	204.61	4.629	**
LL, day	205.04	232.72	3.095	**
ADMY, liter	0.816	0.878	0.168	ns

ns: nonsignificant, **: $P < 0.001$, MY: milk yield, ADMY: average daily milk yield, LL: lactation length, SEM: standard error of the mean.

Table 2. Milk chemical composition of the Awassi ewes in the CF and APG systems.

Variables	Management systems			
	CF ($n = 75$)	APG ($n = 75$)	SEM	P value
Fat (%)	7.96	7.82	0.153	ns
Protein (%)	5.87	6.13	0.066	*
Lactose (%)	4.45	4.47	0.007	ns
Fat : protein ratio	1.38	1.28	0.032	ns
SCC ($\log10$ cells mL^{-1})	2.05	2.04	0.018	ns
pH	6.60	6.61	0.041	ns
EC ($mS\,cm^{-1}$)	4.10	4.00	0.091	ns

*: $P < 0.05$, ns: nonsignificant, EC: electrical conductivity, SEM: standard error of the mean.

ditions, from physiological processes such as estrus or an advanced stage of lactation (Raynal-Ljutovac et al., 2007). Gonzalez-Ronquillo et al. (2021) found that year, farm, number of lambing, and each of the meteorological factors had a significant effect ($P < 0.0001$) on SCC, and the value was 743.915 ± 405 cells mL^{-1} in Churra ewes. An increase in SCC causes a decrease in milk yield and affects milk composition, which leads to reduced milk product shelf life and quality. Roca et al. (2019) reported that EC and SCC were significantly affected by mammary gland health status, milking fraction, and lactation number. Uhrincat et al. (2019) showed that the depletion of lactose and an increase in SCC, EC, and protein contents were significantly affected by the presence of pathogens. In this study, the SCC log10 values (2.05–2.04) of sheep fed in two different production systems were found to be lower than the values reported by Roca et al. (2019), 2.04–2.21, the Sobrino et al. (2018) log bulk-tank somatic cell count (logBTSCC), 6.02, the Kawecka and Pasternak (2020) values of 5.98–5.95, the Uhrincat et al. (2019) value of 4.89, and Kasapido et al. (2021)'s 3.271–3.288 cells mL^{-1}. This situation may have been caused by the milking hygiene rules applied in the enterprise, breed, and other factors. In this study, the average milk electrical conductivity values of Awassi sheep were determined to be 4.01–4.05 $mS\,cm^{-1}$. The average of the electrical conductivity values was generally found to be similar to studies by Gelasakis et al. (2018), 4.0, Kasapido et al. (2021), 4.42–4.4, Doğan and Boztepe (2012), 4.42, Roca et al. (2019), 3.80–4.07, and Uhrincat et al. (2019), 4.63 $mS\,cm^{-1}$. Similar re-

sults in our study and other reports indicate that the electrical conductivity of milk remains unaffected by the production system. The difference might be found among the different breeds or seasons of milking.

The acidity of the milk indicates the freshness and withstanding ability of milk against heating. When milk is expressed, it shows a slightly acidic reaction. The natural acidity of milk is primarily composed of casein, phosphate, citrates, second-degree albumin, globulin, and carbon dioxide. Since the natural acidity of milk is related to the substances in its composition, the acidity levels of different compositions will also be different. For example, the acidity of sheep and buffalo milk, which has a high protein content, is higher than that of cow's milk.

Daş et al. (2022) measured pH on days 45, 75, 105, and 135, with values of 6.7, 6.55, 6.02, and 5.89. The pH values showed a decreasing trend in value with the number of days passing, which is different from our findings. The pH value measured in the milk of Awassi sheep shows similarities to the Park et al. (2007) pH, 6.51–6.85, Sobrino et al. (2018) pH, 6.61, Gelasakis et al. (2018) pH, 6·7, Hamad and Baiomy (2010) pH, 6.6, Govari et al. (2019) pH, 6.69–6.70, and Kasapido et al. (2021) pH, 6.70–6.70. These reports suggest that the pH value of milk remains constant in the different production systems and normally is not easily disturbed by the production system.

3.3 Milk fatty acid composition and nutritional value

Values for the fatty acid composition of milk are presented in Table 3. Sheep milk fatty acid composition is given in Table 3. Palmitic (C16:0), myristic (C14:0), stearic (C18:0), capric (C10:0), and lauric (C12:0) acids were the major saturated fatty acids in milk from both production systems. The levels of linolenic acid (C18:2 n-6) were found to differ statistically ($P < 0.05$) in milk from the CF and APG management systems.

Daş et al. (2022) measured the composition of fatty acids in Awassi sheep under semi-intensive conditions, and the fatty acid records in their study showed higher values. However, the values of palmitic acid (C16:0) and stearic acid (C18:0) were higher in our study. Yakan et al. (2019) recorded a total of 22 fatty acids (from C4:0 to C24:0) for both feeding strategies, and a significant difference was seen between the short-chain fatty acids (from C4:0 to C10:0) in the feeding strategies. Five fatty acids (C10:0, C14:0, C16:0, C18:0, and C18:1) accounted for >75 % of the total fatty acids in goat and sheep milk. These results are similar to our study. Papaloukas et al. (2016) found that, regarding the short-chain (C4) and medium-chain (C6:C12) saturated fatty acids, butyric (C4:0), caproic (C6:0), caprylic (C8:0), capric (C10:0), and lauric (C12:0) acids were found to be significantly lower in summer milk ($P < 0 \cdot 001$). Kasapido et al. (2021) showed that grazing can improve the fatty acid composition of milk. Thus, pasture-based feeding strategies could improve the fatty acid composition and nutritional properties of sheep dairy products. The farming system did not affect the milk's chemical composition and physicochemical characteristics. However, milk fatty acid composition and nutritional values were significantly improved in milk from farms using the semi-intensive production system, and this favorable effect was attributed to the inclusion of pasture in the sheep diet. These results are different from the result in our study in that there was no difference between confined or grazing management systems in terms of milk fatty acids.

The milk fatty acid composition profile for CF and APG for most of the fatty acids was not very different in both groups, but in the case of C4:0, C6:0, C16:0, C16:1, and C18:0, significant variation among CF and APG was seen. Five fatty acids (C10:0, C14:0, C16:0, C18:0, and C18:1) account for >75 % of the total fatty acids in goat and sheep milk (Park et al., 2007). The major fatty acids were C16:0, C18:1 n-9 cis, C18:0, and C14:0, with percentages higher in Gutierrez-Pena et al. (2021) than 9.5 % of the total fatty acids. The Youssef and Abi Saab (2022) findings showed the highest amount of lauric (C12:0), myristic (C14:0), and palmitic (C16:0) acids at the end of lactation. In addition, stearic acid (C18:0) showed a constant trend in the beginning and middle of lactation, but towards the end, the values dropped. However, the highest amounts of isomer (C18:1t; C18:2t) and CLA (C18:2 c9t11) were seen at 30 d of lactation towards the end of March. Gomez-Cortes et al. (2009) compared the fatty acid performances of three groups of Assaf ewes, grazing without supplementation, grazing with TMR (ad libitum), and grazing on pasture with oat grain (PS) supplementation. The recorded milk yield was lowest in the PS group and highest in the TMR group. The PS group also showed the lowest fat, total solid, and milk protein content. The atherogenicity index C12:0, C14:0, and C16:0 were higher in the TMR group 3.22, and they were similar in the grazing, 1.53, and PS, 1.54, groups. The PS group reported higher levels of cis-9 C18:1 and C18:0 in milk than the grazing-only group, but it reported lower amounts of α-linolenic acid. Trans-11 C18:1 and cis-9 trans-11 levels were lowest in PS, 0.58, 0.59 g 100 g^{-1} of total fatty acids, highest in grazing only, 1.21, 3.88 g 100 g^{-1} of total fatty acids, and, in TMR, 0.72, 1.92 g 100 g^{-1} of total fatty acids. The lowest levels of trans-10 cis-12 C18:2 and trans-10 C18:1 were recorded in the milk of the grazing-only group.

Bodnar et al. (2021) reported that, while grazing, the amounts of linolenic (C18:3), stearic (C18:0), caprylic (C8:0), oleic (c9C18:1), caproic (C6:0), romanic (c9t11C18:2), butyric (C4:0), and vaccenic (t11C18:1) acids were significantly increased. However, the amounts of palmitoleic (C16:1), myristoleic (C14:1), lauric (C12:0), palmitic (C16:0), capric (C10:0), and linoleic (C18:2) acids were decreased significantly by grazing.

The effect of the production system on the lipid quality of milk is given in Table 4. The effect of the production system on the SFAs, MUFAs, and PUFAs was nonsignificant ($P > 0.05$) in the milk from the CF and APG production systems.

Bodnar et al. (2021) reported that grazing increased the total number of n-3 PUFAs significantly, while on the other hand the number of medium-chain fatty acids (MCFAs), odd-chain fatty acids (OCFAs), n-6 PUFAs, PUFAs, and n-6/n-3 were significantly decreased by grazing in the milk and cheese of goats.

Daş et al. (2022) recorded higher values of SFAs in Awassi sheep; however, the values of MUFAs, PUFAs, and UFAs were higher in our study than their findings. De Renobales et al. (2012) recorded higher numbers of total unsaturated fatty acids (PUFAs) and unsaturated FAs in the sheep with more grazing time and less hay than the other group, who had less grazing time and more hay. Group 1 with more grazing time reported more amounts of c9t11, vaccenic acids, CLA, and short- and medium-chain fatty acids than the other group, with the concentration being 3.4 more for these FA folds than the control group. In the FAs detected, the saturated FAs had 75 %, with most of them being short-chain fatty acids and stearic acid and not atherogenic acids. The sheep group with more grazing time reported 56 % more non-atherogenic FAs than the control group, which had 49 % of these FAs. Bonanno et al. (2016) studied the effect of grazing the Comisana breed with ryegrass for 8 and 22 h d^{-1} and on sulla grass for 8 and 22 h d^{-1} without feeding supplementation. Milk pro-

Table 3. Fatty acid composition of the Awassi ewes in the CF and APG management systems.

Variables	Management systems		SEM	P value
	CF (n = 25)	APG (n = 25)		
Saturated fatty acids (%)				
Butyric acid (C4:0)	2.92	2.66	0.062	*
Caproic acid (C6:0)	2.30	2.09	0.055	*
Caprylic acid (C8:0)	2.18	2.01	0.068	ns
Capric acid (C10:0)	6.85	6.48	0.243	ns
Lauric acid (C12:0)	4.20	4.06	0.150	ns
Myristic acid (C14:0)	12.34	13.24	0.260	ns
Palmitic acid (C16:0)	34.06	31.95	0.535	*
Margaric acid (C17:0)	0.66	0.73	0.033	ns
Stearic acid (C18:0)	8.82	11.64	0.325	**
Arachidic acid (C20:0)	0.27	0.27	0.016	ns
Monounsaturated fatty acids (%)				
Palmitoleic acid (C16:1)	1.304	1.084	0.039	**
Heptadecenoic acid (C17:1)	0.29	0.37	0.035	ns
Oleic acid (C18:1)	20.75	21.55	0.585	ns
Eicosenoic acid (C20:1)	0.23	0.230	0.224	ns
Polyunsaturated fatty acids (%)				
Linoleic acid (C18:2)	2.04	1.59	0.114	*
Linolenic acid (18:3)	0.40	0.40	0.018	ns

*: $P < 0.05$ and **: $P < 0.01$, ns: nonsignificant, SEM: standard error of the mean.

duction, fatty acid composition, and physicochemical properties of milk were recorded. Ewes grazing on sulla grass showed higher milk production, high dry matter intake, lower fat, and higher casein in milk than ewes grazing on ryegrass. The sulla group with 22 h of grazing showed lower milk fat, higher milk yield, and increased nutrient and dry matter (DM) intake than the sulla group with 8 h of grazing. Furthermore, the sulla group showed FA composition to be healthier for consumption than ryegrass, because of higher levels of PUFAs and n-3 FAs and lower levels of saturated FAs. However, the sulla group with 8 h grazing time showed a better FA profile than 22 h grazing, with a healthier index due to higher levels of rumenic acid (c9, t11-C11:2), monosaturated FAs, branched-chain FAs, and PUFAs. Therefore, the shorter grazing time on sulla grass showed a better cheese FA profile and a healthy index, while the milk yield and nutrient intake along with DM were better with longer grazing time. We reported no significant difference in the fatty acid profile overall between the CF and APG management systems. However, the abovementioned studies have reported results different from our study. This variation in results can be explained by the grazing approach and supplementation with grazing. The abovementioned studies report supplementing the grazing animals with different nutrition apart from grazing which might have been the cause of increasing the amounts of certain fatty acids while decreasing the amounts of other certain

fatty acids. We suggest that the application of grazing with the provision of extra supplemented feed can change the fatty acid profile of milk; however, the grazing and confined management of ewes without extra supplemented feed might not change the fatty acid profile significantly.

According to Papaloukas et al. (2016), the available pastures in semi-extensive farming systems can contribute to the production of high-quality milk. The significant variability was mostly attributed to the diet. Specifically, the pasture-based diet during the months of spring and especially summer resulted in the amelioration of important ratios, indices, and groups of FAs in sheep's milk. Muldasheva et al. (2021) showed that milk from the semi-intensive production system had significantly improved fatty acid composition and lipid quality nutritional indices in relation to milk produced on intensive farms. Differences in the composition of fatty acids and the lipid quality indices were attributed to the inclusion of pasture in the sheep diet.

Table 4 gives the sums, ratios, and index values obtained from fatty acids. The h/H ratio, TI, and n3/n6 were affected significantly ($P > 0.05$ in both production systems). AI and HPI values were higher in milk from the confined production system than in milk from the grazing management system (Table 4).

The h/H ratio was significantly higher ($P < 0.05$) in the milk of the APG management system than in the CF man-

Table 4. Milk nutritional indices of the Awassi ewes in the CF and APG management systems.

Variables	Management systems		SEM	*P* value
	CF	APG		
SFA	74.031	74.788	0.536	ns
MUFA	21.865	22.654	0.571	ns
PUFA	3.078	1.501	0.650	ns
UFA	24.820	23.479	0.690	ns
h/H	0.817	0.967	0.032	*
AI	3.701	3.900	0.137	ns
TI	0.410	0.370	0.007	**
HPI	0.289	0.270	0.011	ns
DFA	33.641	35.122	0.882	ns
n3/n6	0.170	0.271	0.019	*

*: $P < 0.05$ and **: $P < 0.0$, SFA: saturated fatty acid, MUFA: monounsaturated fatty acid, PUFA: polyunsaturated fatty acid, DFA: desirable fatty acid, SEM: standard error of the mean.

agement system. Kasapidou et al. (2021) reported h/H ratio values of 0.560–0.688 for ewe's milk. Santos-Santos-Silva et al. (2002) reported that a higher h/H index is desired. The h/H ratio is used to explain the effect of fatty acid composition on cholesterol and its relevance to cardiovascular disease. This is associated with the functional activity of fatty acids in lipoprotein metabolism for the transport of plasma cholesterol. AI was not significantly higher ($P > 0.05$) in the milk of APG than of CF. Kasapidou et al. (2021) reported that ewe's milk ranges between 2.825 and 2.355 for a semi-intensive production system, in contrast to milk from a confined production system. However, the TI was also significantly higher ($P < 0.05$) in the milk from the confined system. The reported range for TI was 1.00–2.72 (Kasapidou et al., 2021). Papaloukas et al. (2016) found AI ranges of $39 \cdot 32$ and 45.0 and TI ranges of 1.95 and 3.07, and Gutierrez-Pena et al. (2021) reported an AI ratio value of 2.71, a TI value of 3.08, and an HPI value of 0.37 for ewe's milk. The AI indicates the relationship between the sum of essential saturated fatty acids and the sum of the major classes of unsaturated fatty acids, which defines the thrombogenic potential of fatty acids and refers to the state of clot formation in blood vessels (Paszczyk and Łuczyńska, 2020). Fats with higher AI and TI values are considered to be more detrimental to human health. The pasture-based management implemented during spring and summer caused a decrease in AI and TI in milk. HPI and DFA had similar values in the milk from ewes in the CF and APG systems ($P > 0.005$). However, the Kasapidou et al. (2021) content of DFA was significantly higher ($P < 0.001$) in the milk from the semi-intensive production system. Similarly, the reported range for HPI was 0.16–0.28 for the milk of Comisana ewes. Sinanoglou et al. (2015) found AI values of 2.22, 1.89, and 1.91, TI values of 1.22, 1.12, and 1.12, and h/H values of 0.59, 0.69, and 0.66 in Chios ewes. Their AI results agree with our study; however, the TI value was higher than this study's results, and the

h/H value was slightly higher than for CF and APG ewes. These statements indicate that the animals raised on grazing or semi-intensive production systems provide healthier milk nutritional indices as compared to a confined and intensive production system. Therefore, milk from grazing animals or a semi-intensive production system can be healthier for human consumption as compared to milk from a confined system.

4 Conclusions

The lactation milk yield and lactation length of sheep managed based on artificial pasture were found to be better than the feeding system based on concentrated feed. However, in this study, it was determined that there was no significant difference between the two management systems in terms of the chemical characteristics and quality of the milk of Awassi sheep. Although milk yield, chemical composition and quality characteristics of milk, and nutritional value are mostly influenced by the feeding and rearing systems of animals, factors such as breed, age, and season are also important. More studies are needed to reveal the seasonal and economic analysis and efficiency of two management systems in different seasons on milk composition, milk production, fatty acid, and milk nutrient content.

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