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Characterisation of Volatile Compounds and Composition of Milk of Kilis Goats Reared at Two Different Locations

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ABSTRACT

Various factors such as species, breeds, lactation stage and location affect milk composition. We evaluated the composition of Kilis goat milk in two different seasons on the basis of alcohols, ketones, aldehydes, esters, indoles, carboxylic acids, aromatic hydrocarbons and terpenes. Milk samples were collected at the early and late lactation periods from Hatay and Kilis, Turkey. During both periods, the goats consumed a diversity of plant species. Milk collected from Kilis had 15.27-16.10% total solids,5.70-6.50% fat and 4.80-5.10% protein. The lactose content did not differ significantly between milk samples from the two locations (3.90-4.20%). Total unsaturated fatty acid levels were significantly higher than total saturated fatty acid contents, irrespective of the lactation period ($p<0.05$). Milk from Hatay was high in saturated fatty acids, aromatic hydrocarbons and benzaldehydes, i.e. 4.50 g 100 g^{-1}, 6.80-4.65 mg 100g^{-1} and 0.28-0.70 mg 100g^{-1}, respectively. Throughout the lactation period, the levels of total solids, fat, protein, saturated and unsaturated fat, alcohol, ketones, esters and carboxylic acid increased, while indole, terpene, aromatic hydrocarbon and aldehyde contents decreased.

INTRODUCTION

In recent years, goat breeding has become more profitable than cattle and sheep breeding due to changes in global climate and precipitation regimes and increased soil salinity (Silanikove, 2000). Goats are more adaptable to arid environments because of their feeding behaviour, the digestion of high-fibre fodder in the rumen, their water metabolism and their capacity to store and later mobilise body reserves; they are therefore capable of adjusting the widely varying feeding situations (Morand-Fehr, 1991). About 500,000 domestic goats of the total 11 million goats in Turkey are Kilis goats. This breed is endemic and used in the southeastern regions (Kilis, Gaziantep, Hatay and Sanlıurfa) of Turkey (Daskiran *et al*., 2018). It has a black and brown fur coloration and long pendulous ears; its hair is straight, long and coarse. Animas of this breed are seasonal breeding animals for both meat and milk production and endangered genetic resources in Turkey (Tasdemir *et al*., 2011). The Kilis goat is the most important domestic goat breed for high milk yield; it is highly resistant to adverse environmental conditions and diseases (Anonymous, 2018). Milk yield and lactation time vary among different studies: 300-400 kg per lactation and 210-260 days (Iriadam, 2007), 250-400 kg and250-300 days (Cetin *et al*., 2009). According to the communiqué about race and line registration of domestic animals in Turkey, on average, milk yield is 217.4 kg (70.3-269.6 kg) and lactation time is 228 days (178-257 days) (Anonymous, 2018; Agaoğlu and Ertugrul, 2012).

Kilis goats reared in Hatay and Kilis are indigenous breeds and the most important source of milk for the rural population (Aslantas *et al*., 2005). The area contains meadows (16%), shrubland (12%) and forests (6%) and represents the transition area between the Southeast Anatolian steppe and the Mediterranean vegetation (maki), with Mediterranean vegetation being dominant in Hatay (Anonymous, 2019). Climatic and environmental conditions affect the aroma of dairy products. For example, the milk

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of animals grazing in meadows in a dry environment and at high elevations, rich in dicotyledon plants, has a more fruity and dried taste (Martin *et al*., 2005).

Milk composition varies among breeds, feeds, lactation stages, seasons, etc. (Silanikove *et al*., 2010). Goat milk contains twice as many short- and medium-chain fatty acids than cow milk (Raynal-Ljutovac *et al*., 2008). It also has a stronger flavour and aroma than other types of milk. According to previous studies, the branched and short-chain fatty acids (FAs) with less than 11 carbon atoms, such as caprylic, capric and caproic FAs, are responsible for the typical "goaty" aroma (Ha and Lindsay, 1993; Salles *et al*., 2002; Verruck *et al*., 2019). The β-oxidation of PUFA could increase the amount of degradation products such as straight-chain aldehydes and ketones, which may be converted to alcohols, forming volatile components (Cais-Sokolinska *et al*., 2015).

Goat milk protein is more digestible for humans than cow milk protein and has a lower amount ofαs_1-casein (Costa *et al*., 2014). The casein micelles from goat milk are different from those of cow milk; goat milk has a low resolution, thermal stability and sedimentation rate, a high cold solubility of β-casein, a small micelle size and high calcium and phosphorus levels (Haenlein, 2004). Few studies have focused on the effects of foodstuff on goat milk composition, especially in terms of volatile compounds (Muelas *et al*., 2018), but no scientific data is available regarding the effects of different locations and lactation periods on the volatile profile of goat milk. In this context, we aimed to describe the changes in the composition of Kilis goat milk during the lactation period and to evaluate the influences of location and lactation periods on fatty acid and volatile profiles of the milk of Kilis goats.

MATERIALS AND METHODS

Milk of Kilis goats was collected from two separate locations (Kilis and Hatay cities) in two different periods. Kilis is located in the transition zone between the Mediterranean and Southeast region (36° 42′ 59.3136 and 37° 6′ 52.7832") at an average elevation of 680 m above sea level. Hatay is the most southern province of Turkey (36° 0′ 47.1168" and 36° 7′ 20.1684") and situated at an average elevation of 450 m above sea level. Milk samples (early lactation period) were collected from April 10 to 20 in Kilis and from 20 to 30 April in Hatay. Late-lactation samples were taken from October 15-20. The samples were collected from 16 Kilis goats, with three samples at regular intervals of 7 days. The milk samples were combined to obtain two samples per period, divided into two parts and immediately frozen at -18°C.

A Fourier transform infrared milk analyser (Milkoscan FT 120, FOSS Electric, Hillerød, Denmark) was used for determination of total solids, protein, fat, total saturated (SFA) and unsaturated (UFA) fatty acids, total monounsaturated fatty acids (MUFA)and polyunsaturated fatty acids (PUFA). The amounts of SFA, UFA, MUFA and PUFA were expressed as g FA/100 g milk. Volatile compounds of the goat milk samples were analysed via static headspace solid-phase micro extraction (SPME), using a gas chromatography-mass spectrometry system (Shimadzu Corporation, Kyoto, Japan) (Hayaloglu *et al*., 2007). A duplicate 3.0-g portion of the sample was then placed in a 15-mL vial, followed by 10 µL of internal standard containing 81 mg/kg of 2-methyl-3-heptanone in methanol (Sigma-Aldrich Co. USA) and allowed to equilibrate at 40°C for 30 min. Essentially, extraction is achieved by injecting a 2-cm 50/30 µm divinyl benzene-carboxen-polydimethylsiloxane (DVB/CAR/PDMS) fibre (Supelco, Bellefonte, PA, USA) into the vial and exposing it to the headspace for 30 min at 40°C. The fibre was positioned at 3.0 scale units in each run. Desorption of the extracted volatiles was carried out in a Shimadzu GC-2010 gas chromatography - QP-2010 mass spectrometry system (Shimadzu Corporation, Kyoto, Japan), run in splitless mode. During desorption, the fibre remained in the injector for 2 min at a temperature of 250°C, with helium as carrier gas at a flow rate of 1.0 mL/min. The volatile compounds were separated in a DB-Wax column (60 m × 0.25 mm × 0.25 um; J and W Scientific, Folsom, CA, USA). The oven temperature was held at 40°C for 2 min (desorption period), then increased at 5°C per min to 70°C and held for 1 min. The temperature was then raised at 10°C per min to 240°C to provide a run time of 30 min. The mass spectrometer was set to record at 33 to 450 amu (threshold 1,000) at a sampling rate of 1.11 scans/s. The volatile compounds were identified by calculation of the retention index (RI) of each compound, using an *n*-alkane series (C_8 to C_{20}) under the same conditions. The peak identifications were based on comparison of the mass spectra of unknown compounds with those in the Wiley 7 (7^{th} edition) and NIST/EPA/NIH 02 mass spectral libraries. Identifications were also confirmed by comparing retention times with reference standards when available. About 30 authentic standard compounds (Sigma chemical Co., St. Louis, MO) were used to confirm volatiles in the obtained cheese samples. The RI values were also compared with those described in the literature, determined under the same conditions for matching the compounds. The results were calculated by comparison of the peak area of the internal standard and the unknown compounds. Each compound was expressed as mg/100 g of sample.

Statistical analysis

Variance analysis was performed by Shapiro-Wilk and Bartlett's tests. The fixed effects were breed, lactation stage and breed x lactation stage interaction. The covariance structure was autoregressive order 1, and the degrees of freedom were adjusted by the Kenward-Rogers method. Mean separation of significant effects ($P < 0.05$) was conducted by SAS (1999). Least squares means and SEM are reported for all data.

RESULTS AND DISCUSSION

Milk composition

At the late lactation, the levels of total solids, fat, protein, total UFA, SFA, MUFA and PUFA ratios in the goat milk were increased in both locations (Table I); this result is in agreement with previous findings (Mestawet *et al*., 2012; Chen *et al*., 2017). Total solids, fat, protein, total UFA, SFA and MUFA contents were highest in Kilis at early lactation. The total solid content of milk from Kilis was similar to the 13.88-16.27% reported by Mestawet *et al*. (2012), but lower than the 17.5% observed by Casey and Van Niekerk (1988). The fat and protein contents ranged between 4.2-6.5% and 3.6-5.1%, respectively. The fat content was lower than that observed in a study in South Africa with Boer goat milk, but similar to the findings of other studies, which reported7.5-6.1% fat and 4.3-5% protein, respectively (Greyling *et al*.,2004; Mestawet *et al*., 2012). These differences are most likely due to different environmental conditions and feeding strategies. At late lactation, the milk components in milk from Hatay were more highly concentrated than in milk from a cross breed in Ethiopia, with 13.88%total solids, 3.65%fat and 4.08% protein (Mestawet *et al*., 2012); milk from Maltese goats from Italy had relatively low levels of protein (3.4%) and fat (3.5%) (Carnicella *et al*., 2008). The protein and fat compounds of milk are significantly affected by the season, age and nutrition (Mestawet *et al*., 2012). Goats prefer leaves over stems, thick stems over thin ones and the protein parts over the carbohydrate parts (Morand-Fehr, 1991). In the early lactation period, the high protein content of goat milk from Kilis may be a result of the high protein level of the forage in this region. The lactose contents of milk samples from both regions were lower than the values found by Guo *et al*. (2004) with 4.47% and Prasad *et al*. (2005), who reported levels of well above 5.5%.

Milk FA composition is affected by rumen biohydrogenation and Δ9-desaturase enzyme conversion (C18:0 into C18:1, Bauman and Griinari, 2003), but considerable changes in the milk fat composition can be achieved by dietary changes (Liu *et al*., 2016). The total SFA content of goat milk was higher in milk from Hatay location than in milk from Kilis in the late lactation period. Differences in the diet can lead to differences in the saturated and unsaturated fatty acid profiles of milk (Calderon *et al*., 1984). We observed a significant difference ($P < 0.05$) between total UFAs and SFA content in both early and late lactation periods. The mean contents of total SFAs (3.00-4.50 g100 g^{-1}) were comparable to the values found in milk from Saanen or Alpine goats (3.34-4.02 g100 g^{-1}; Le Doux *et al*., 2002) fed TMR or different level of forages. However, Alpine goats raised in feedlots provided milk with low total SFA contents (1.08-2.68 g100 g^{-1}) (Bernard *et al*., 2005).

Unsaturated fatty acids are the precursors of dairy aromas and are reduced by microbial enzymes in the rumen (Martin *et al*., 2005). Total UFAs showed the highest levels (0.86 and 2.0 g100 g^{-1}) in the milk fat of goats at different lactation stages ($P < 0.05$); the total UFA levels were higher in milk from Kilis compared to milk from Hatay (Fig. 1), irrespective of the lactation period. This suggests that the proportion of unsaturated fatty acids is higher in milk from high elevations than in milk from low elevations. The concentration of unsaturated fatty acids in goat milk varies with fodder plants (Alvarenga *et al*., 2015). The UFA content of Kilis goat milk were higher than those of Saanen and Swedish Landrace goat milk samples. Yurcenko *et al*. (2018) reported 25.80 g 100 g^{-1} UFA in the total FA of Saanen goat fat, equivalent to 0.86 g 100 g^{-1} UFA in the total FA of goat milk. These differences might be due to the higher amount of dicotyledon species in the diet of Kilis goats.

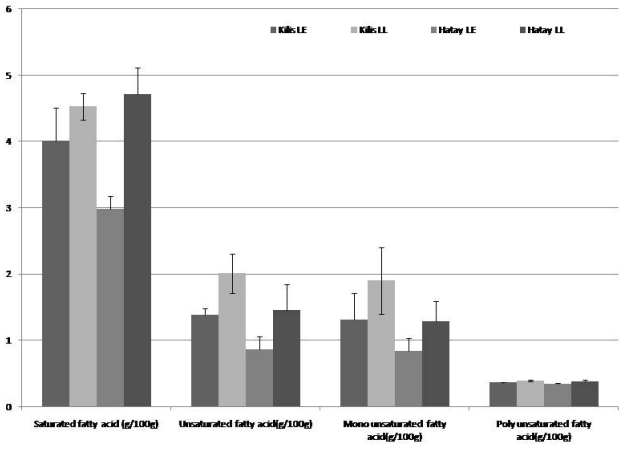

Fig. 1. Change of saturated and unsaturated fat content during laction period.

The total MUFA level in goat milk from both regions ranged between 1.20-1.30 and 0.85-1.40 g $100g^{-1}$,

respectively. A low monounsaturated fatty acid level in caprine milk (0.37-0.50 g 100 g^{-1}) has been determined by Alonso *et al*. (1999), while Talpur *et al*. (2009) have reported an elevated level (4.02-4.61 g 100 g^{-1}) in goat milk fat. There were no significant differences (P >0.05) in the total PUFAs of goat milk between the two locations and lactation periods, similar to the findings of Talpur *et al*. (2009) for two local breeds (Kamori and Pateri) in Pakistan. Ruminant milk fat consists of 65-70% SFA, 25-30% MUFA and 5-10% PUFA (Schwendel *et al*., 2014). Cais-Sokolinska *et al*. (2015) have reported 30.74 g 100 g^{-1} MUFA in the total FA of goat fat, equivalent to 1.03 g 100 g^{-1} MUFA in the total FA of goat milk.

Throughout the lactation stages, the milk components showed high variations in milk from Hatay at the late lactation period. The levels of total solids, fat, protein, saturated and unsaturated fatty acids were significantly higher (P <0.05) in the late lactation period than in the early lactation period; similar results have been described by Guo *et al*. (2004). Dry matter levels were highest at the end of the lactation period. Based on the lactation curve of goats, in the early lactation period, the total solid content is low, along with a high milk quantity. The opposite pattern was observed for the late lactation period.

The differences in the lactose contents of the milk from the same goat breed, but different locations, were not statistically significant (P >0.05). In both locations, lactose contents were high in the early lactation period, with subsequent decreases; this has also been observed by Prasad *et al*. (2005). The protein and total PUFA concentrations increased throughout the lactation period in both locations due to increasing herbage sugar content because of the accumulation of photosynthesis products (Avondo *et al*., 2008).

Volatile compounds of goat milk from different locations

All volatile compounds of milk from Kilis and Hatay are shown in Table II. A total of 58 volatile compounds were identified, including 4 indoles, 7 terpenes, 8 ketones, 5 aldehydes, 8 carboxylic acids, 7 alcohols, 18 aromatic hydrocarbons and 2 esters. Table III also shows the statistical evaluation of the differences in lactation periods and location in terms of the volatile components. Of the 58 components, 22 were present in both lactation periods and in the milk of both locations. According to Muelas *et al*. (2018), ketones (sweet, buttery and creamy flavours), acids and alcohols (alcoholic and floral-fruity notes) in fermented dairy products have different aroma perceptions. Acetic and lactic acids contribute to the acidic aroma, while butanoic, hexanoic and octanoic acids are responsible for the goaty and cheesy aroma. The major volatile compounds detected in Kilis goat's milk were α- pinene, dl-limonene, cymene, capric acid, 2- octanol and 4-nonanol, irrespective of the location. The lactation period affected the amounts of volatiles in goat milk. While the amounts of terpenes, aldehyde and aromatic hydrocarbons significantly decreased during the lactation period, indoles, ketones, carboxylic acids and alcohols increased for both locations (P <0.05).

The amount of 3-methylindole (skatole), derived from tryptophan degradation, in milk from Hatay was higher than that in milk from Kilis in both lactation periods (1.77 to 0.84 mg 100 g^{-1}). Previous studies have shownhigh amounts of skatole in the milk of grazing animals (Prache *et al*., 2005; Schreurs *et al*., 2008). In the late lactation period, 2-3-N-phenylimino indole and 1H-Indole were not detected.

The terpene content did not significantly differ between the two lactation periods (17.68 versus 8.58 mg/100 g) in milk from Kilis, but decreased significantly (*P* <0.05) from early to late lactation (27.36 versus 11.76 mg/100 g)in milk from Hatay location. The terpenes α-pinene, dl-limonene and β-phellandiene were the most abundant terpenes, irrespective of the location and lactation period (P<0.01). According to a previous study, higher herbage intake modifies the digestive and metabolic processes (Fedele *et al*., 2005), and terpenes can be used to determine the geographical origin of animals that graze pastures (Prache *et al*., 2005). The terpene contents of the milk samples from both locations varied, mainly because the plant species *Geranium tuberosum, Arum dioscoridis*, *Asparagus acutifolius*, *Asphodelus aestivus, Gynandriris sisyrinchium* and *Ophrys lutea* are found in Kilis grassland, while *Muscari babachii*, *Scilla autumnalis, Gladiolus italicus, Orchis simia* and *Cephalanthera longifolia* are more common in Hatay. Boutoial *et al*. (2012, 2013) have observed that addition of aromatic plants, such as rosemary and thyme, to goat diets increased the levels of PUFAs, protein, dry matter and lactose. Sant'Ana *et al*. (2019) have detected higher α-pinene concentrations in goat milk obtained from goats grazing native pastures of a semiarid region of Brazil compared with milk from animals kept under confinement.

In milk from Kilis, the ketone levels increased significantly (*P* <0.05) from early lactation (1.65 mg/100 g) to late lactation (1.76 mg 100 g^{-1}), mainly because of the conversion of secondary alcohols to methyl ketones. 2-octanone, 4-nonanone, furanone and 3-buten-2-one compounds were found in the goat milk in both lactation period. Of these, 2-octanone, which has a fruity aroma (Fedele *et al*., 2005), was detected in higher concentrations in milk from the lactation period and from Kilis. The fat content seems to have an influence on the concentration of ketones (Vazquez-Landaverde *et al*., 2005), and in our

Table I. The changes in milk composition of Kilis goat breed from Hatay and Kilis locations during lactation period.

	Kilis		Hatay		SEM	Location	Lactation period	Location × Lactation period
	EL	LL	EL	LL				
Total solids (%)	15.27	16.10	12.70	16.30	1.11	0.31	0.07	0.25
Fat (%)	5.70	6.50	4.20	6.50	1.03	0.53	0.18	0.50
Protein (%)	4.80	5.10	3.60	5.10	0.37	0.13	0.03	0.14
Lactose (%)	4.20	3.90	4.30	4.00	0.18	0.44	0.11	0.92
Total UFA ($g100g^{-1}$)	1.30	2.00	0.86	1.60	0.34	0.27	0.06	0.94
Total SFA($g100g^{-1}$)	4.00	4.30	3.00	4.50	0.87	0.65	0.32	0.47
Total MUFA ($g100g^{-1}$)	1.20	1.30	0.85	1.40	0.24	0.15	0.04	0.96
Total PUFA ($g100g^{-1}$)	0.30	0.43	0.35	0.40	0.03	0.68	0.14	0.74

UFA, Unsaturated fatty acid; SFA, Saturated fatty acid; MUFA, Monounsaturated fatty acid; PUFA, Polyunsaturated fatty acid; EL, Early lactation; LL, Late lactation, SEM, Standard error of the mean.

Table II. All volatiles compounds (mg $100g^{-1}$, mean ± SD) during lactation period (df= 9) in Kilis breed goat milk from Hatay and Kilis.

Compounds	RI	HEL	KEL	HLL	KLL
Carboxcylic acid					
Acetic acid	1467	nd	nd	0.052±0.01b	0.407±0.02a
Benzoic acid	1160	0.261±0.02c*	0.262±0.03c	0.504±0.02a	0.305±0.03b
Octanoic acid	2083	nd	0.990±0.03a	0.103±0.04c	0.220±0.02b
Caproic acid	1850	nd	0.272±0.03	nd	nd
Hexadecanoic acid	1951	0.013±0.02	nd	nd	nd
Capric acid	1809	0.346±0.04d	1.478±0.02a	0.686±0.04b	0.567±0.02c
Tetradecanoic acid	1748	nd	nd	nd	0.078±0.02
Lauric acid	1554	nd	0.052±0.03	nd	nd
Alcohols					
Ethanol	931	11.457±0.09d	20.913±0.06c	25.242±0.06b	28.368±0.05a
2-Octanol	981	13.890±0.04c	16.002±0.04b	20.541±0.04a	20.560±0.04a
4-Nonanol	1076	19.156±0.04c	21.892±0.04b	28.405±0.04b	28.425±0.03a
2-Ethyl-1-hexanol	1484	0.032±0.01	nd	nd	nd
1-Butanol	1137	0.022±0.01	nd	nd	nd
Fluoren-9-ol	1108	0.051±0.01	nd	nd	0.040±0.01
1,4-Butanediol	1252	0.034±0.01	nd	nd	nd
Indoles					
3-methylindole (skatole)	1070	0.835±0.03b	1.765±0.02a	0.255±0.03b	0.808±0.04b
N-ethyl-1,3-dithioisoindoline	1617	7.535±0.20a	1.092±0.05b	0.753±0.02c	1.467±0.02b
2-3-N-phenylimino indole	1085	0.160±0.02	nd	nd	nd
1H-Indole	1257	0.038±0.02b	0.190±0.03a	nd	nd
Aromatic hydrocarbon					
Benzene, ethenylmethyl	1833	1.660±0.50b	3.390±0.20a	1.304±0.60c	0.568±0.40d
1-ethenyl-3-ethyl- benzene	1145	3.858±0.30a	3.145±0.60b	1.786±0.04c	0.400±0.20d
1-ethenyl-4-ethyl- benzene	1132	1.790±0.02b	2.010±0.02a	1.015±0.02c	0.540±0.04d

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Compounds	RI	HEL	KEL	HLL	KLL
Aromatic hydrocarbon					
Cyclopropylcarbinol	1148	nd	nd	0.217±0.01b	0.670±0.03a
Cyclobutanol	1252	0.105±0.02b	nd	0.119±0.02b	0.293±0.03a
2,4,6-Cycloheptatrien-1-one	1106	0.340±0.02b	0.072±0.04c	0.690±0.03a	nd
Ethylbenzene	843	0.016±0.01b	0.295±0.04a	nd	nd
o-Xylene	1151	0.028±0.02	nd	nd	nd
p-Xylene	1149	0.031±0.01	nd	nd	nd
3-O-5,7,3',4'-tetra o-methylquercetin	1079	0.019±0.02	nd	nd	nd
4,8,9b-Triazacyclopenta phenalene	1276	0.331±0.02a	0.293±0.02a	0,.180±0.03b	nd
Benzenesulfonylchloride	1150	0.122±0.02b	0.018±0.01c	0.035±0.02c	0.250±0.03a
2-5-thiazolyl thyocyanate	935	nd	nd	0.323±0.03a	0.170±0.02b
1-allyl-2,8-dimethoxy-9H-carbazole	1092	0.267±0.02a	0.155±0.04b	nd	0.138±0.02b
2-Chloro-4-6-pyrimidine	1221	0.063±0.02a	nd	0.042±0.02a	nd
1,3-diethenyl	1226	0.562±0.02a	0.125±0.04b	0.037±0.02c	0.025±0.02c
3-Phenylcyclopentene	981	0.043±0.03a	0.022±0.04b	nd	nd
Furanone	1530	0.027±0.04b	nd	0.013±0.01c	0.080±0.02a
5-Ethylindan	1177	0.062±0.02a	0.025±0.01c	0.041±0.01b	nd
Methoxy-phenyl- /oxime	1115	0.305±0.01c	nd	0.691±0.02b	1.195±0.05a
Esters					
Hexanoic acid ethyl ester	905	nd	0.527±0.03	nd	nd
Decanoic acid ethyl ester	1823	0.037±0.04c	0.572±0.03a	nd	0.152±0.02b
Terpenes					
Styrene	1273	0.705±0.01b	0.750±0.01b	0.247±0.02c	1.003±0.01a
3-Isopropoxy-1,1,1,7,7,7-hexam-ethy1-3,5,5, tristetrasiloxane	1400	0.257±0.02a	nd	0.071±0.01c	0.150±0.01b
Silanediol	1442	0.283±0.02a	0.152±0.03b	0.070±0.02c	nd
α-iron	1191	0.103±0.02b	0.248±0.02a	0.052±0.02c	0.030±0.01c
Ketones					
2-Octanone	964	0.575±0.03c	0.560±0.01c	0.727±0.05b	0.910±0.03a
4-Nonanone	1076	0.249±0.02d	0.355±0.04c	0.727±0.04a	0.657±0.02b
2-Propanone	1201	nd	nd	0.047±0.02	nd
2-Heptanone	1175	0.406±0.02b	0.512±0.03a	nd	0.170±0.02c
2-phenyl-3,7-dimethyl-octane	1207	0.026±0.02	nd	nd	nd
Ethanone	985	0.015±0.02	nd	nd	nd
3-Buten-2-one	1014	0.199±0.01a	0.178±0.02a	nd	0.028±0.03b
2-Methylindanone	1118	0.041±0.02a	0.053±0.02a	nd	nd
Aldehydes					
2-Propenal	1419	0.140±0.01a	0.093±0.02b	0.051±0,03b	nd
Benzaldehyde	941	0.509±0.02a	0.315±0.02b	0.150±0.04c	0.165±0.02c
Cinnamaldehyde	1234	0.064±0.02	0.017±0.03b	nd	nd
4-Methylcinnamaldehyde	1185	0.016±0.02	nd	nd	nd
2-Furancarboxaldehyde	1108	nd	nd	nd	0.132±0.05

*Means ± SD within a row with no common superscript differ (P<0,05).
Nd, not detected; RI, retention index using alkane series (C8 to C20) under the same chromatographic conditions; HEL, Hatay earllactation; KEL, Kilis early lactation; HLL, Hatay late lactation; KLL, Kilis late lactation.

Table III. Changes in volatile compounds (mg 100g^{-1}, mean) of Kilis breed goat milk from Hatay and Kilis locations during both lactation period (df= 9).

	Hatay		Kilis		SEM	L	LP	LxLP
	EL	LL	EL	LL				
3-methylindole	0.84	1.77	0.26	0.81	2.24	0.89	0.02	0.86
N-ethyl-1.3-dithioisoindoline	0.75	1.09	0.75	1.47	1.86	<0.01	0.01	0.01
Total indoles	1.59	2.86	1.01	2.28				
α-pinene	7.00	2.00	15.80	2.50	1.81	0.02	<0.01	0.04
dl-limonene	4.00	1.90	3.70	2.70	0.55	0.68	0.01	0.31
β-phellandiene	2.00	2.20	1.90	2.50	0.14	0.24	0.01	0.18
Cymene	3.10	0.80	3.90	2.50	0.65	0.09	0.01	0.49
n-terpene	0.82	1.60	1.00	1.10	0.17	0.25	0.02	0.07
α-Iron	0.30	0.07	0.28	0.19	0.05	0.39	0.02	0.27
Camphene	0.46	0.01	0.78	0.27	0.31	0.39	0.18	0.92
Total terpenes	17.68	8.58	27.36	11.76				
2-Octanone	0.56	0.87	0.58	0.91	0.08	0.73	<0.01	0.89
4-Nonanone	0.53	0.87	0.55	1.00	0.14	0.54	<0.01	0.61
Furanone	0.62	0.48	0.10	0.06	0.05	0.02	0.01	<0.01
3-Buten-2-one	0.05	0.51	0.45	0.14	0.29	0.96	0.80	0.22
Total ketones	1.76	2.73	1.68	2.11				
Benzaldehyde	0.48	0.26	0.70	0.28	0.19	0.53	0.12	0.62
Benzoicacid	0.39	0.37	0.36	0.5	0.67	0.52	0.47	0.30
Capricacid	1.50	1.70	0.38	0.76	0.34	0.01	0.42	0.84
Total carbocylic acids	1.78	2.07	0.74	1.26				
Styrene	1.10	2.00	1.00	0.90	0.29	0.05	0.19	0.13
Benzene.ethenylmethyl	3.00	1.10	1.90	2.00	0.41	0.83	0.05	0.03
1-ethenyl-4-ethyl- benzene	2.00	1.10	1.80	1.60	0.31	0.65	0.09	0.25
1.3-diethenyl benzene	0.26	0.06	2.10	0.15	0.46	0.08	0.05	0.10
Total aromatic hydrocarbons	6.36	4.26	6.80	4.65				
2-Octanol	16.00	20.60	13.90	20.50	1.60	0.51	<0.01	0.52
4-Nonanol	21.90	28.40	19.20	28.40	2.39	0.57	<0.01	0.58
Total alcohols	37.90	49.00	33.10	48.90				

EL, Early lactation; LL, Late lactation; L, Location; LP, Lactation period; SEM, Standard error of the mean.

study, the total ketone amount was higher for the 5.73% (Kilis) with respect to the 4.24% (Hatay) fat sample.

The highest amount of benzaldehyde has detected in milk from the early lactation period from Kilis, and the amount of five ketone compounds decreased during lactation, with the exception of 2-furancarboxaldehyde. However, even at low concentrations, aldehydes significantly contribute to the aroma of the milk (Vazquez-Landaverde *et al*., 2005).

Carboxylic acids are precursors of other aroma compounds, such as methyl ketones, alcohols, lactones, aldehydes and esters (Collins *et al*., 2003; Delgado *et al*., 2011). The amounts of carboxylic acid at the early and late lactation periods were higher in milk collected from Kilis. Previous studies have found that medium-chain fatty acids contribute to the goaty aroma (Silanikove *et al*., 2010), such as hexanoic (C6:0) and capric (C10:0) acid, while others have reported that octanoic acid has a rancid and pungent odour (Salles *et al*., 2002). Acetic acid was present in the late lactation period both locations and can be associated with the slightly tarty taste of Ibores cheese (Delgado *et al*., 2011). The amounts of benzoic and capric

acid in milk from Hatay were relatively low in the early lactation period (Table II). Lauric acid may be the reason for bitter, rancid and unclean flavours (Clark and Mora Garcia, 2017). In milk from the early lactation period and from Kilis, the lauric acid content was 0.052 mg $100g^{-1}$. In a previous study, the amounts of hexanoic (caproic), octanoic, decanoic (capric) and dodecanoic (lauric) acids differed between Nubian and Alpine goat breeds, with Kilis goats presenting more of each of these aromatic compounds (Attaie *et al*., 1993).

Four aromatic hydrocarbons (styrene, benzene-ethyl methyl, 1-ethyl-4-ethyl benzene and 1.3-diethyl benzene) of the 18 components identified in milk from the two different locations were determined in both lactation periods. Aromatic hydrocarbons were identified in the milk samples, of which styrene and benzene-ethyl methyl were the most abundant ones. The levels of aromatic hydrocarbons were lower in milk from Kilis, while styrene and benzene-ethyl methyl were higher in milk from Hatay.

Ethanol, 2-octanol and 4-nonanol increased significantly ($P < 0.05$) throughout the lactation period in both locations. Secondary alcohols are formed by enzymatic reduction (alcoholdehydrogenase) of the corresponding methyl ketones (Molimard and Spinnler, 1996), and the increase in alcohols may be due to a reduction of grasses and an increase in the plant diversity over time (Fedele *et al*., 2005). Sant'Ana *et al*. (2019) have found 1-butanol, 1-hexanol and maltol in Sannen X American Alpine goat milk and suggested that these compounds are responsible for fruity and herbaceous flavours. Kilis goats can consume a wide range of plants due to their agility, mobile upper lips and tendency to assume a bipedal stance, apart from their higher salivary secretion and urea recycling capacity. The development of the salivary glands allows even the consumption of forage crops with bitter taste (Morand-Fehr, 1991). In cheese production, the milk type affects the volatile profile of cheeses (Delgado *et al*., 2011).

CONCLUSIONS

The composition of the milk from Kilis goats was significantly affected by lactation period and location. Milk from goats reared in Kilis showed a better profile in terms of total solids, fat, protein, unsaturated fat, alcohol, ketones and carboxylic acids when compared to milk from Hatay. Adequate feeding strategies for milk goats are important to improve the nutritional value of the milk and to increase economic gains. The volatile acid profile of milk varies depending on the origin of the animal.

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Statement of conflict of interest

The authors have declared no conflict of interest.

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