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Evaluation of milk characteristics of Gazvini goats and their F_1 and F_2 crosses with Saanen

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Abstract The present study aimed to evaluate the effects of crossbreeding on milk yield, physical and chemical composition and fatty acid profiles of milk fat in Qazvini goats and its crosses with Saanen goats. Records of 316 lactations and 1745 test-day milk were available for Qazvini (Q), Qazvini×Saanen (QS), and QS×Saanen (QSS) goats. The least squares means and standard errors of daily milk yield in Q, QS, and QSS goats were 716±75, 1188±61, and 1373±107 g/day, during the lactation length of 163, 160 and 166 days, respectively. In Q milk, the percentages of total solids, fat, protein, lactose and ash, and the density (-1000, g L^{-1}) and freezing point (-°C) were 15.12, 6.01, 3.39, 4.91, 0.80, 29.91 and -0.601 being higher (P<0.01) than those of crossbred goats (except for milk density). Concentration of milk saturated fatty acids (SFA) and polyunsaturated fatty acids (PUFA) for Q, QS, and QSS were 68.31, 67.42, 75.34, and 2.74, 4.10 and 3.25 g/100g total fatty acids, respectively (P<0.05). Concentration of mono-unsaturated fatty acids (MUFA) for those groups were 20.16, 19.18 and 18.43 g/100g total fatty acids, respectively (P>0.05). Despite decreased concentration of milk components, crossbreeding might be recommended in increasing the milk production and the amount of PUFA fatty acids in Qazvini goats.

Keywords: crossbreeding, fatty acid profile, milk, Qazvini goat, Saanen

Introduction

Goat farming is a common and popular practice in the world, with goat products having a special market (Pollott and Wilson, 2009). The number of goats has increased globally, despite major changes in agriculture due to industrial mergers, globalization, and technological advances in developed countries (Gooki et al., 2019). The indigenous genetic resources play an important role in food production and nutrition security in dry regions of the world (Ogola and Kosgey, 2012). Goat milk production has increased significantly in the past decades and goats play an important role in milk production worldwide, as it represents an economical substitute to milk from cattle in developing countries, especially in dry and harsh environments (Klir et al., 2015).

The consumption of goat milk is often recommended by healthcare professionals due to its nutritional advantages for people with health problems (de Cardona et al., 2017). There are about 1.52% of the world 1.34 billion goats in Iran (FAOSTAT, 2019a). Currently, the ranking of Iran in goat milk production and milk production per head is 14^{th} and 84^{th} in the world, respectively

(FAOSTAT, 2019b). Hence, considering the more extended period needed to achieve genetic progress by selection within breeds strategy, crossbreeding of indigenous goats with more productive pure breeds may be recommended for supplying the increased demands of goat milk production. For example, daily milk yield of local goat breeds in Kenya increased from 0.61 to 1.08 kg (Bett et al., 2011) and total milk production of local goat breeds in Southern Tunisia increased 2.5-fold (Gaddour et al., 2009). Also, the total milk production of native goats in Romania and India increased by 38 and 77 percent, respectively (Serradilla, 2001; Shelton, 1986).

The Qazvini goats (Q) in Iran are kept under an extensive traditional system mainly for meat and milk production. These goats are well adapted to the harsh regions and produce an acceptable amount of milk and meat in the low-input rearing system. Due to the government's policy of removing native small ruminant from pastures and developing intensive systems, the need for genetic improvement of local breeds by cross breeding to increase production per head is felt more than ever.

Saanen goats as a dairy breed have often been used to improve the milk production in native breeds (Güzeler et al., 2010; Serradilla, 2001). Currently, crossbreeding is one of the important breeding strategies for increasing goat milk production in Iran (Hosseini et al., 2017). Due to the high cost of raising goats in intensive systems, quantitative and qualitative evaluation of milk produced by crossbred goats in this breeding system is necessary. Therefore, the objective of this study was to evaluate the quantity and quality characteristics of milk production in Qazvini goats and their crosses with Saanen goats.

Materials and methods

Study area

The current study was used the data collected at the Fakhr-e-Iranian farm in Qazvin province of Iran. This farm is located at the latitude of 23.5°N and longitude of 89°E, and an altitude of 1280 m above mean sea level.

Animals, management, and feeding

The data were obtained from 69, 107 and 18 Qazvini (Q), Qazvini×Saanen (QS), and QS×Saanen (QSS) does, raised under the same environmental conditions and managed in an intensive system from 2016 to 2018. The does were mated with 11 Saanen bucks, while avoiding the mating of the daughters with their sires. The mating system is shown in Figure 1.

Table 1. Chemical composition (%) of alfalfa and concentrate mix

Composition	Alfalfa	Concentrate mix
Dry matter	88	90
Crude protein	16.5	20.4
Ether extract	3.2	6.6
Ash	8.7	6.5
Neutral detergent fiber	43	14.6
Metabolizable energy (MJ/kg^{-1} DM)	2.1	2.95

All animals were regularly vaccinated against the major epidemic diseases in Iran (i.e., foot and mouth disease, anthrax, and goat pox) and treated in for internal and external parasites, and other treatments whenever needed. The goats were fed with alfalfa hay and concentrate mix according to their maintenance, milk production, and growth requirements (Table 1).

Sampling and measurements

The goats were machine-milked by (8:00 AM and 4:00 PM) and fed (9:00 AM and 5:00 PM) twice per day. The test-day milk records were collected monthly from kidding until drying off. Depending on the milking capacity, the time of drying off fluctuated between the third and seventh months of lactation. The first milk recording was set between 15 days and one month after kidding. The kids were allowed to suckle their dams freely until the first milk recording. The kids were then weighed and kept on a residual suckling regimen in which they were allowed to obtain the residual milk for 10 minutes, and were weighed again. The difference between the first and second weights, as the residual milk, was added to the milk harvested by the milking machine. Milk samples were taken monthly from the morning and afternoon milking and analyzed for fat, solids-not-fat (SNF), lactose, ash, protein, density and freezing point by using an ultrasonic milk analyzer (Milkotronic Ltd, Bulgaria) that was calibrated for the goat milk. In this study, 316 lactations and 1,745 test-day milk records were measured from the three genotypic groups (Table 2).

Table 2. The number of lactation periods by genotypic group and year of study

Goat genotype	Years		
	2016	2017	2018
Q	73	47	-
QS	28	106	38
QSS	-	9	15

Q: Qazvini; QS: Q×Saanen, and QSS: QS × Saanen goat

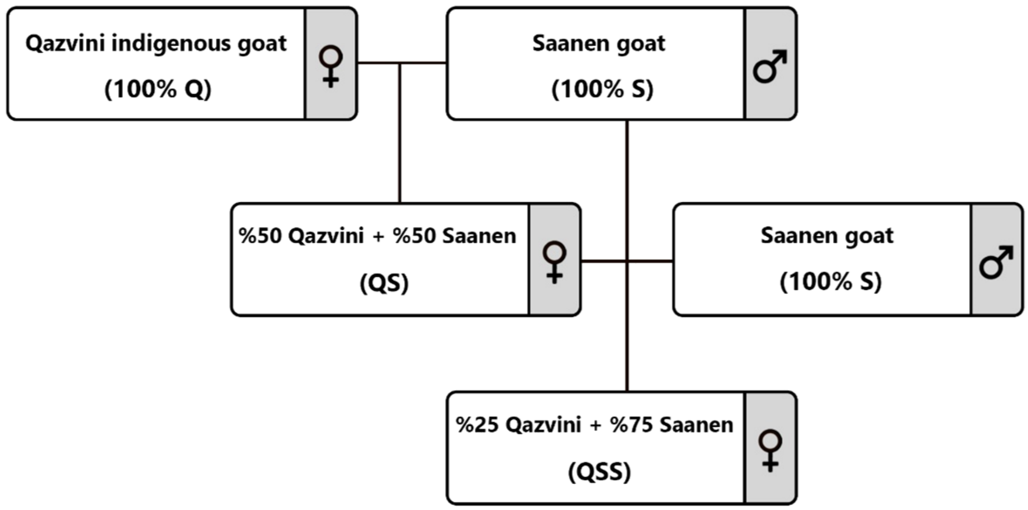

Figure 1. The crossbreeding system between the Qazvini and Saanen goats

Milk fatty acids were determined in samples collected on months 1, 3 and 5 of the lactation in 18, 21, and 15 Q, QS, and QSS does. Milk fat was extracted, and fatty acids methylated according to Bouattour et al. (2008). Briefly, 0.1 g of the milk fat was mixed with 2 mL of KOH (1 M), and then 5 mL of 14% boron trifluoride in ethanol added. The samples were methylated by incubation at 100 °C for 60 min and extracted with 5 mL hexane. The fatty acid methyl esters in the hexane layer were analyzed by a gas chromatograph (3400 Varian Star; Varian Inc., Palo Alto, CA) equipped with CP-SIL-88 capillary column (60 m×0.25 mm, Varian), with helium as the carrier gas. The column temperature was initially 50 °C for 1 min, increasing by 4 °C/min to 190 °C. The temperature of the injector was set 280 °C, and that of the detector at 300 °C (Emami et al., 2016).

Statistical analysis

Data were analyzed using the PROC MIXED for repeated measurements in the SAS program (SAS, 2004). The data on daily milk yield, physical, chemical composition and fatty acid profiles of milk fat were analyzed by applying the following statistical model:

$$y_{ijklmno} = \mu + G_i + A_j(G_i) + R_k + L_l + S_m + P_n + M_o + G_i \times M_o + e_{ijklmno}$$

where $y_{ijklmno}$ is observations; μ is overall mean, G_i is the fixed effect of the ith genotypic group (i = Q, QS and QSS), A_j (G_i) is the random effect of animal within genotypic group ~N(0, $\sigma^2_{\text{Animal (Genotypic group)}}$), R_k is the fixed effect of the kth year of kidding (k = 2016 to 2018), L_l is the fixed effect of the Lth litter (L=singleton and twin), S_m is the fixed effect of the mth season of kidding (m = spring to winter), P_n is the fixed effect of the nth lactation of dam (m = 1 to 5), M_o is the fixed effect of the oth month of lactation (o = 1 to 7), $G_i \times M_o$ is the interactions between the fixed effects of genotypic group and month of lactation and $e_{ijklmno}$ is the random residual effect ~N(0, σ_e^2). The fatty acid profile in milk fat was determined in 17, 20 and 9 milk samples from Q, QS and QSS genotypes, collected in 2017. The model included the genotype and lactation as the fixed effects. Due to the non-significant effects of lactation, only the fixed effect of genotype was included in the final model. Comparisons of means were carried out using the Tukey's (P≤0.05).

Results

Milk yield, physical characteristics and chemical composition

The least squares means of daily milk production for Q, QS and QSS goats were 716, 1188 and 1373 g/day, (Table 3), in lactation length of 163, 160 and 166 days, respectively with significant differences between Q indigenous and crossbred goats (P<0.01). The lactation length was not affected by the genotype.

Among the three genotypic groups, Q goats had the highest performance in terms of milk total solids, fat, lactose, ash, protein content and freezing point (P<0.01), except for density. There was no significant difference between QS and QSS goats for milk physical and chemical characteristics, except for the ash content (P<0.01). The milk freezing point in Q milk (-0.601°C) was lower than that of QS and QSS crossbred goats (P<0.01).

Table 3. Least square means (± SEM) of the fixed effects and genotypic groups for daily milk yield and lactation length

Effects	n	Morning milk yield (g)	Afternoon milk yield (g)	Daily milk yield (g)	n	Lactation length (day)
Genotype	1745	**	**	**	316	NS
Q	153	469^{b}±53	248^{b}±27	716^{b}±75	121	163±8
QS	1068	797^{a}±43	393^{a}±21	1188^{a}±61	172	160±8
QSS	524	941^{a}±75	434^{a}±37	1373^{a}±107	23	166±14
Year of kidding	1745	**	**	**	316	**
2016	427	606^{b}±54	315^{b}±26	917^{b}±76	101	119^{b}±9
2017	1001	805^{a}±37	405^{a}±18	1208^{a}±53	163	186^{a}±6
2018	317	797^{a}±56	356^{ab}±27	1151^{a}±79	52	183^{a}±10
Season of kidding	1745	**	**	**	316	**
Spring	561	605^{b}±42	288^{c}±21	891^{b}±60	98	143^{c}±7
Summer	130	845^{a} ±63	470^{a}±31	1312^{a} ±89	32	164^{b}±11
Autumn	628	810^{a}±41	362^{b}±20	1171^{a}±58	107	187^{a}±7
Winter	426	683^{ab}±49	314^{bc}±24	995^{b}±69	79	156^{b}±9
Parity	1745	**	**	**	316	**
1	411	574^{b}±48	294^{b}±24	868^{b}±69	67	192^{b}±9
2	641	732^{ab}±41	337^{ab}±20	1067^{b}±58	99	199^{a}±7
3	362	757^{a}±47	402^{ab}±23	1257^{a}±66	75	167^{c}±8
4	186	778^{ab}±66	372^{ab}±32	1149^{ab}±93	44	149^{c}±12
5	145	736^{ab}±84	388^{ab}±41	1119^{ab}±118	31	108^{d}±8
Type of birth	1745	NS^{a}	NS	NS	316	NS
Singleton	1371	756±34	362±41	1115±48	253	157±6
Twin	374	716±44	355±17	1069±62	63	169±8
Month of lactation	1745	**	**	**	-	-
1	316	1041^{a}±36	513^{a}±18	1552^{a}±51	-	-
2	316	1082^{a}±36	513^{a}±18	1595^{a}±51	-	-
3	316	910^{b}±36	435^{b}±18	1345^{b}±51	-	-
4	272	724^{c}±37	346^{c}±18	1068^{c}±52	-	-
5	203	581^{d}±38	277^{d}±19	855^{d}±54	-	-
6	188	481^{de}±45	246^{d}±23	720^{de}±64	-	-
7	134	332^{e}±71	181^{d}±37	509^{e}±99	-	-
Genotype×Month of lactation	1745	NS	NS	NS	-	-

Q: Qazvini; QS: Q×Saanen, and QSS: QS × Saanen goat.

NS: No significant P>0.05; * significant P≤0.05; **significant P≤0.01.

[a,b]Within each column and for each subclass, the means with common superscript(s) do not differ P>0.05.

The effects of year of kidding were significant (P<0.01) on all traits investigated in this study (Tables 3 and 4). The effects of lactation number (parity) were significant (P<0.01) on milk yield. The first-lactation goats produced the lowest daily milk per day (P<0.01). The milk yield increased progressively with the parity until the third lactation (Table 3). A slight decrease in the milk yield in the fourth and fifth lactations was observed. In addition, milk physical and chemical characteristics (P<0.01) were affected by parity (Table 4). Goats in fifth-lactation produced (P<0.01) lower total solid and fat, but higher protein, lactose, and ash contents. Kidding season affected the investigated traits (Tables 3 and 4) but the effect of litter size on lactation length was not significant (Table 3). Lactation length in twin bearing goats was 7.64% longer than in singleton goats.

The month of lactation significantly impacted on the daily milk yield and milk physical and chemical characteristics (Tables 3 and 4). In Q goats, the highest daily milk production was recorded in the first and second months of lactation (Figure 2). In QS and QSS goats, the highest daily milk production was achieved in the second month of lactation.

Milk lactose and protein concentrations were higher in the Q goats than QS and QSS crossbreds (P<0.01), except at the seventh month of lactation (Table 4 and Fig-

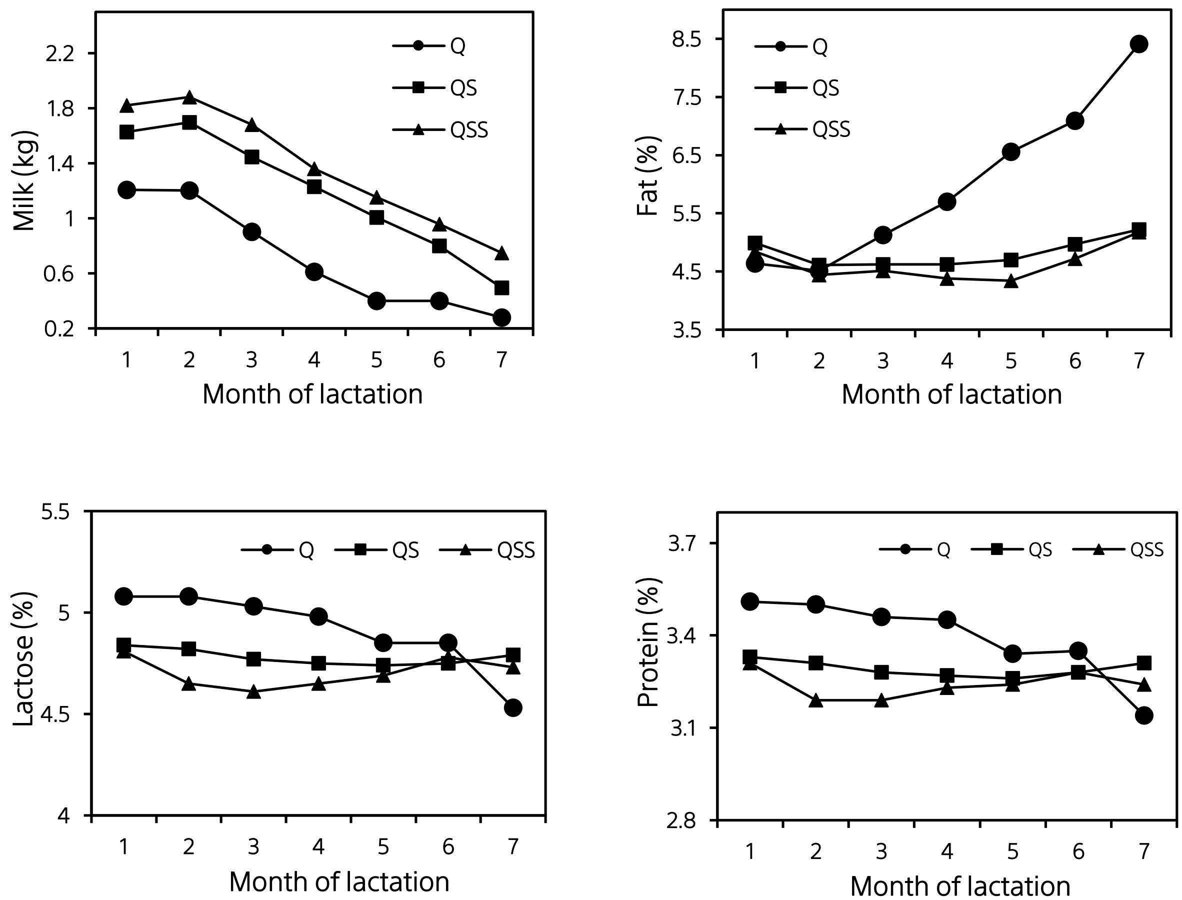

Figure 2. Daily milk yield (kg), Fat concentration (%), Lactose concentration (%), Protein concentration (%) of genotypic groups over months of lactation, Q: Qazvini; QS: Q×Saanen, and QSS: QS × Saanen goat.

ure 2). Lactose content was almost stable during lactation in all genotypic groups. Milk protein content slightly tended to decrease in the Q goats in which their milk yield showed a decreasing trend.

The milk fat content in all genotypic groups decreased from the first to second month of lactation, and after that tended to increase until the end of lactation (Figure 2). The milk fat content of Q goats was lower than that of QS and QSS crossbred goats in the early lactation, but in the third and seventh months of lactation, the fat content of milk in Q goats was higher than other groups ($P<0.01$).

Milk fatty acid profiles

The effect of the genotypic groups on some of fatty acid profiles was significant ($P<0.05$, Table 5). The C16:0 level was the highest in total goat milk fatty acids, followed by C18:1 9c, C10:0, C14:0, C18:0, and C6:0 fatty acids, respectively. These fatty acids constituted about 71.75% of the total fatty acids.

The saturated fatty acids (SFA) in Q, QS and QSS were 68.31, 67.42 and 75.34%, respectively ($P<0.05$). Within the SFA, significant differences were observed for C4:0, C6:0, C8:0, C10:0, C12:0, C15:0 and C20:0 values. The QSS goats showed higher concentrations of C4:0, C8:0, C10:0, C12:0, and C15:0 than that of QS crossbreds. In contrast, Q and QS goats had higher concentrations of C6:0 and C20:0, respectively.

The monounsaturated fatty acid (MUFA) concentration was 20.16, 19.18, and 18.43% for Q, QS, and QSS goats, respectively ($P>0.05$). Among the MUFAs, C18:1,12*c* was highest in QSS goats ($P<0.05$).

The proportion of polyunsaturated fatty acid (PUFA) ranged from 2.74 to 4.10% for three genotypic groups. The QS goats had a higher proportion of PUFA compared with the Q goats ($P<0.05$). Concentrations of C18:2 *n6* in milk fat of crossbred goats was higher than in Q goats ($P<0.05$). The conjugated linoleic acid (CLA)

Table 4. Least square means (± SEM) of the fixed effects and genotypic groups for milk physical and chemical characteristics

Effects	n	Traits						
		Total solid (%)	Fat (%)	Protein (%)	Lactose (%)	Ash (%)	Density (-1000,g.L^{-1})	Freezing point (-°C)
Genotype	1745	**	**	**	**	**	NS^{a}	**
Q	153	15.12^{a}±0.16	6.01^{a}±0.17	3.39^{a}±0.03	4.91^{a}±0.04	0.80^{a}±0.01	29.91±0.27	0.601^{a}±0.01
QS	1068	13.65^{b}±0.12	4.82^{b}±0.13	3.29^{b}±0.02	4.78^{ab}±0.03	0.77^{b}±0.01	29.36±0.22	0.569^{b}±0.01
QSS	524	13.31^{b}±0.21	4.63^{b}±0.23	3.24^{b}±0.03	4.70^{b}±0.05	0.75^{c}±0.01	28.36±0.39	0.558^{b}±0.01
Year of kidding	1745	**	**	**	**	*	**	**
2016	427	13.57^{b}±0.16	4.53^{b}±0.17	3.37^{a}±0.02	4.90^{a}±0.04	0.78^{a}±0.01	30.26^{a}±0.28	0.585^{a}±0.01
2017	1001	14.14^{a}±0.11	5.35^{a}±0.11	3.28^{b}±0.02	4.75^{b}±0.03	0.77^{b}±0.01	29.00^{b}±0.19	0.571^{b}±0.01
2018	317	14.38^{a}±0.16	5.58^{a}±0.17	3.27^{b}±0.03	4.75^{b}±0.04	0.77^{b}±0.01	28.91^{b}±0.28	0.573^{b}±0.01
Season of kidding	1745	**	**	**	**	**	**	**
Spring	561	13.63^{b}±0.13	4.84^{b}±0.13	3.27^{b}±0.02	4.75^{b}±0.02	0.76±0.02	29.15^{b}±0.20	0.568^{b}±0.01
Summer	130	14.77^{a}±0.18	5.90^{a}±0.19	3.30^{ab}±0.03	4.80^{ab}±0.04	0.78±0.04	29.04^{b}±0.32	0.581^{ab}±0.01
Autumn	628	14.04^{a}±0.12	4.97^{b}±0.13	3.38^{a}±0.02	4.91^{a}±0.03	0.79±0.03	30.16^{a}±0.21	0.587^{a}±0.01
Winter	426	13.68^{b}±0.14	4.90^{b}±0.15	3.28^{b}±0.02	4.75^{b}±0.03	0.76±0.03	29.22^{b}±0.25	0.568^{b}±0.01
Parity	1745	**	**	**	**	**	**	**
1	411	14.37^{a}±0.14	5.44^{a}±0.15	3.33^{b}±0.02	4.82^{b}±0.03	0.78^{a}±0.01	29.45^{b}±0.25	0.583^{ab}±0.01
2	641	14.22^{a}±0.12	5.44^{a}±0.13	3.27^{b}±0.02	4.75^{b}±0.03	0.77^{b}±0.01	28.88^{b}±0.21	0.573^{b}±0.01
3	362	14.11^{a}±0.14	5.38^{a}±0.15	3.26^{b}±0.02	4.72^{b}±0.03	0.76^{b}±0.01	28.84^{b}±0.24	0.567^{b}±0.01
4	186	14.10^{a}±0.19	5.42^{a}±0.15	3.23^{b}±0.03	4.70^{b}±0.05	0.76^{b}±0.01	28.50^{b}±0.34	0.562^{b}±0.01
5	145	13.35^{b}±0.24	4.08^{b}±0.26	3.45^{a}±0.04	5.03^{a}±0.04	0.80^{a}±0.01	31.29^{a}±0.43	0.596^{a}±0.01
Type of birth	1745	NS	NS	NS	NS	NS	NS	NS
Singleton	1371	14.00±0.10	5.12±0.11	3.31±0.02	4.80±0.02	0.77±0.01	29.42±0.18	0.577±0.01
Twin	374	14.06±0.13	5.18±0.14	3.30±0.02	4.80±0.03	0.77±0.01	29.37±0.22	0.575±0.01
Month of lactation	1745	**	**	**	**	**	**	**
1	316	13.90^{b}±0.11	4.82^{c}±0.12	3.38^{a}±0.02	4.91^{a}±0.04	0.79^{a}±0.01	30.25^{a}±0.19	0.588^{a}±0.01
2	316	13.47^{c}±0.11	4.52^{d}±0.12	3.33^{b}±0.02	4.85^{b}±0.04	0.77^{b}±0.01	29.88^{ab}±0.19	0.578^{b}±0.01
3	316	13.64^{bc}±0.11	4.75^{cd}±0.12	3.31^{bc}±0.02	4.81^{bc}±0.04	0.77^{b}±0.01	29.52^{bc}±0.19	0.573^{b}±0.01
4	272	13.77^{b}±0.11	4.90^{c}±0.12	3.31^{bc}±0.02	4.80^{bc}±0.04	0.77^{b}±0.01	29.46^{cd}±0.19	0.573^{b}±0.01
5	203	14.02^{b}±0.12	5.21^{bc}±0.12	3.28^{c}±0.02	4.76^{c}±0.04	0.77^{b}±0.01	29.15^{cd}±0.20	0.572^{b}±0.01
6	188	14.47^{a}±0.15	5.59^{ab}±0.15	3.30^{bc}±0.02	4.79^{bc}±0.04	0.78^{a}±0.01	29.25^{cd}±0.23	0.578^{b}±0.01
7	134	14.94^{a}±0.24	6.27^{a}±0.25	3.23^{c}±0.04	4.68^{c}±0.04	0.77^{b}±0.01	28.23^{d}±0.36	0.570^{b}±0.01
Genotype×Month of lactation	1745	**	**	**	**	**	**	**

Q: Qazvini; QS: Q×Saanen, and QSS: QS × Saanen goat.
NS: No significant P>0.05; * significant P≤0.05; **significant P≤0.01.
^{a,b} Within each column and for each subclass, the means with common superscript(s) do not differ P>0.05.

concentration in the milk fat of genotypic groups, and the ratio of n-6/n-3 fatty acids not affected by genotypic groups (P>0.05).

Discussion

Results of the present study demonstrate that crossing Qazvini goats with Saanen goats is an appropriate strategy for improving milk production. In a similar study, Hoseini et al. (2011) reported a daily milk yield of 0.48 kg for Iranian Lori black goat and 1.1 kg for its crossbred with Saanen during five months of lactation. Hosseini et al. (2017) reported 0.65 and 1.31 kg daily milk yield for Iranian Mamasani goat and its crossbreds with Saanen, respectively. Katanos et al. (2005) reported an average daily milk yield 560, 956 and 1139 mL for Greece local goat and their crossbred goats with 50% and 75% Saanen genes pool, respectively. The results of the present study, consistent with these reported indicated that crossing with Saanen breed has improved the production of milk of Qazvini native goats (Figure 2).

The significant effects of year, season of kidding and parity on milk yield traits and milk physical and chemical characteristics may be due to fluctuations in the age, availability of nutrients, increase in dry matter intake and mammary capacity (Ciappesoni et al., 2004; Ishag et al.,

Table 5. Least square means (± SEM) for fatty acids profile g/100 g total fatty acids by genotypic groups

Fatty acid	Genotype		
	Q	QS	QSS
C4:0	3.33^{ab}±0.52	2.72^{b}±0.45	4.24^{a}±0.53
C6:0	7.84^{a}±1.72	5.33^{b}±1.15	6.26^{ab}±1.30
C8:0	3.82^{ab}±0.40	2.96^{b}±0.35	4.88^{a}±0.43
C10:0	14.55^{ab}±1.55	11.76^{b}±1.35	16.61^{a}±1.60
C12:0	4.52^{a}±0.29	3.94^{b}±0.26	4.79^{a}±0.30
C14:0	7.99±0.42	8.16±0.37	9.17±0.43
C15:0	0.49^{b}±0.09	0.64^{ab}±0.07	0.78^{a}±0.09
C16:0	19.91±1.50	23.12±1.31	20.99±1.55
C17:0	0.57±0.09	0.71±0.07	0.53±0.09
C18:0	9.03±0.66	8.19±0.57	7.47±0.68
C20:0	0.26^{b}±0.09	0.51^{a}±0.08	0.36^{ab}±0.10
C22;0	0.25±0.06	0.26±0.05	0.28±0.06
C10:1*c*	0.21±0.05	0.28±0.03	0.27±0.05
C12:1*c*	1.33±0.24	0.85±0.22	0.95±0.24
C14:1*c*	0.61±0.09	0.45±0.08	0.53±0.10
C15:1*c*	0.73±0.12	0.68±0.09	0.48±0.11
C16:1*c*	1.02±0.15	1.13±0.12	0.76±0.15
C17:1	0.36±0.08	0.48±0.05	0.45±0.07
C18:1, *9c*	16.01±1.20	14.59±1.04	13.95±1.23
C18:1,*11c*	1.06±0.25	1.24±0.21	1.69±0.22
C18:1,*12c*	0.29^{b}±0.06	0.31^{b}±0.03	0.47^{a}±0.05
C20:1	0.32±0.07	0.36±0.05	0.34±0.07
C18:2*c n6*	1.66^{b}±0.17	2.50^{a}±0.15	2.16^{ab}±0.18
C18:2*t n6*	0.17^{b}±0.05	0.27^{b}±0.03	0.41^{a}±0.04
C18:3*c n3*	0.45±0.13	0.66±0.11	0.54±0.13
C18:2,*9c,11t CLA*[c]	0.70±0.28	0.85±0.23	0.90±0.42
C18:2,*10t,12c CLA*	0.17±0.06	0.22±0.07	ND[d]
Total CLA	0.79±0.29	0.92±0.24	0.90±0.44
SFA[e]	68.31^{b}±2.84	67.42^{b}±2.47	75.34^{a}±2.93
MUFA[f]	20.16±1.27	19.18±1.11	18.43±1.32
PUFA[g]	2.74^{b}±0.35	4.10^{a}±0.31	3.25^{ab}±0.36
n-6/n-3[h]	4.83±0.70	5.71±0.61	6.16±0.73

Q: Qazvini; QS: Q×Saanen, and QSS: QS × Saanen goat.

[a,b] Within each column and for each subclass, the means with common superscript(s) do not differ P>0.05.

[c] CLA: Conjugated linoleic acid; [d] ND: Not detected; [e] SFA: Saturated fatty acids; [f] MUFA: Monounsaturated fatty acids; [g] PUFA: Polyunsaturated fatty acids; [h] n-6/n-3: 18:2*c n6*+C18:2*t n6* / C18:3*c n3*.

2012; Katanos et al., 2005). Ishag et al. (2011) reported a decreasing trend for milk yield with advancing year of kidding in Saanen goats raised in Sudan. The results showed that the milk yield increased progressively with the parity until the 3rd lactation, which is in contrast to the results reported by Mioč et al. (2008) who stated that the effects of parity on daily milk yield showed an almost steady growing trend from the 1st to 4th lactations in Alpine and Saanen goats in Croatia.

Milk lactose values found in this study ranged from 4.70 to 4.91% (Figure 2) which was consistent with the values reported by Tsiplakou et al. (2010) for local goats in Greece, lower than that of reported by Prasad et al. (2005) for local and crossbred goats in India and higher than that of reported by Delgado-Pertínez et al. (2013) for Payoya goats in Spain. According to the results of this study, Currò et al. (2019) reported that indigenous goats had produced less milk but with more lactose content than Saanen goats. In that study, they evaluated the effects of breed on milk composition of five indigenous Italian (Garganica, Girgentana, Jonica, Maltese, and Mediterranean Red) and Saanen goats. Their results indicated that, with the exception of Garganica, the milk lactose concentration of other breeds was higher than that of in Saanen milk and lactose percentage was highest at the beginning of the lactation. Lactose content was similar among Girgentana, Jonica, Maltese and Mediterranean Red (4.51±0.04%), while Garganica and Saanen (4.26±0.03%) presented a lower content.

Results of milk protein analyses (Figure 2) are within the range reported by other researchers (D'Urso et al., 2008; Strzalkowska et al., 2009). As indicated in Figure 2, the protein concentration of the milk produced by Q goats was higher than that of crossbred goats over the lactation period, except for seventh month of lactation. The observed decreasing trend in milk protein of Q goats is consistent with the findings of Chowdhury et al. (2002) for German Fawn goats, but not with Currò et al. (2019) who observed that the protein content of milk was highest at the end of the lactation period. In another study, Margatho et al. (2018) found that the milk protein produced by Serrana goats decreased until six months of lactation and then increased through the lactation period.

The effect of crossbreeding on milk fat concentration was within the range of values reported by other researchers (Suranindyah et al., 2018; Mioč et al., 2008 and Jaafar et al., 2018). Wanjekeche et al. (2016) reported that the milk fat was 5.06-6.82% for Kenya Alpine and 3.52-6.44% for Toggenburg goats in Kenya. Milk fat showed a declining trend from month 1 to 2 for all genotypic groups, and then increased until the end of lactation. This increase in milk fat concentration may be due to a decreased milk production. Bouattour et al. (2008) reported that *de novo* lipogenesis is usually more active after the peak of lactation. At peak of lactation, most of the dietary fatty acids and fatty acids obtained through the mobilization of adipose tissues is used for providing production energy needs. After the peak, a part of dietary fatty acids would probably be partitioned to conservation in the adipose tissue and another part of ruminal fat precursors used for milk fat synthesis.

On the other hand, Fernandez at al. (2008) demonstrated that in general, fat content was higher at the beginning and the end of lactation. It has indeed been observed that goats with lower milk production had a higher fat percentage. The negative correlation between milk yield and fat percentage is known as the dilution effect (Landau et al., 1993). It seems to be a reason for the increased milk fat after the second month of lactation in all genotypic groups of the current study.

The effect of genotypes on milk fatty acid profile is almost consistent with the findings of Yurchenko et al. (2018), who reported significant differences between Saanen and Swedish Landrace goats in Estonia. The concentration of SFA (67.42 to 75.95% of total fatty acids) were higher than those of 53% to 59% reported by Sedighi-Vesagh et al. (2015) and close to the results of 77% found by Strzałkowska et al. (2009). There are some shreds of evidence that the concentration of MUFA in the total fatty acids of goat milk fat could range from 19% (D'Urso et al., 2008) to 32% (Talpur et al., 2009). The results of the present study were almost the same (18.43-20.16%). Polyunsaturated fatty acids have favorable effects on the health of consumers and consist of around 2.82-5% of total milk fatty acids in goats (Rodriguez-Alcala et al., 2009; Strzałkowska et al., 2009), as also found in the present study. The crossing of Qazvini goats with Saanen increased the SFA contents in the milk fat for QSS and also PUFA for QS. In other words, crossing at the level of 50% of Saanen genes improved milk fatty acids, and, at the level of 75%, had the opposite effect.

Conjugated linoleic acid (CLA) is one of the most valuable fatty acids among the PUFA. Both the acid itself and its isomers (principally C18:2,*9c,11t,* and C18:2,*10t,12c*) are characterized by an exceptionally high biological activity (Park et al., 2007). The ruminant milk fat is the principal source of CLA in the human diet and covers about 75% of the daily requirement of the human organs for this compound (Park and Pariza, 2007). The CLA content of milk fat is affected principally by the PUFA concentration in the ruminant diets. In the study presented here, the goat milk fat CLA content varied between 0.79% to 0.92% of total fatty acids, close to the values reported in other studies (Cívico et al., 2017; Tudisco et al., 2010). However, in this study, CLA contents were not different between the genotypes.

The ratio of n-6/n-3 fatty acids in most people (western diets) is 15:1–16.7:1 (Simopoulos, 2008). According to Simopoulos (2008), an optimal n-6/n-3 fatty acids ratio is specific to different diseases (for example, a ratio of 2.5:1 for colorectal cancer and 5:1 for patients with asthma). The recommended ratio of the n-6/n-3 fatty acids by the World Health Organization and Food and Agriculture Organization expert committee is below 4:1 (Zervas and Tsiplakou, 2011; Simopoulos, 2008). In this study, the ratio of n-6/n-3 fatty acids ranged from 4.83 to 6.16 for the genotypic groups comparable to the values reported by Delgado-Pertí˜nez et al., (2013), and was not different among the genotypic groups.

Conclusions

Crossbreeding between Qazvini goat and Saanen breedsimproved the milk production performance and some fatty acids in the milk fat. The crossbred goats with 50% and 75% Saanen genes produced approxi mately 66%

and 92% more milk than Qazvini goats, but with a lower milk composition compared to indigenous goats. If the price of milk produced is determined by its quality, the gross income from the sale of milk in the group with 75% of Saanen genes will be about 18% higher compared to Qazvini goats.

References

Bett, R.C., Kosgey, I.S., Kahi, A.K., Petersa, K.J., 2011. Definition of breeding objectives and optimum crossbreeding levels for goats in the smallholder production systems. *Small Rumination Research* 96, 16-24.

Bouattour, M.A., Casals, R., Albanell, E., Such, X., Caja, G., 2008. Feeding soybean oil to dairy goats increases conjugated linoleic acid in milk. *Journal of Dairy Scince* 91, 2399-2407.

Chowdhury, S.A., Rexroth, H., Peters, J., 2002. Lactation performance of German Fawn goat in relation to feeding level and dietary protein protection. *Asian-Australasian Journal of Animal Sciences* 15, 222-237.

Ciappesoni, G., Přibyl, J., Milerski, M., Mareš, V., 2004. Factors affecting goat milk yield and its composition. *Czech Journal of Animal Science* 49, 465-473.

Cívico, A., Sánchez, N.N., Gómez-Cortés, P., de la Fuente, M.A., Blanco, F.P., Juárez, M., Achille, A., Marín, A.L.M., 2017. Odd- and branched-chain fatty acids in goat milk as indicators of the diet composition. *Italian Journal of Animal Science* 16, 68-74.

Currò, S., Manuelian, C.L., De Marchi, M., De Palo, P., Claps, S., Maggiolino, A., Campanile, G., Rufrano, D., Fontana, A., Pedota, G., Neglia, G., 2019. Autochthonous dairy goat breeds showed better milk quality than Saanen under the same environmental conditions. *Archives of Animal Breeding* 62, 83-89.

D'Urso, S., Cutrignelli, M.I., Calabro`, S., Bovera, F., Tudisco, R., Piccolo, V., Infascelli, F., 2008. Influence of pasture on fatty acid profile of goat milk. *Journal of Animal Physiology and Animal Nutrition* 92, 405-410.

De Cardona, K.L., Scanapieco, A.D.G., Braun, P.G., 2017. Goat production in El Salvador: a focus on animal health, milking hygiene, and raw milk quality. *Journal of Food Quality* 8951509, 1-7.

Delgado-Pertí˜nez, M., Gutiérrez-Pe˜na, R., Mena, Y., Fernández-Cabanás, V.M., Laberye, D., 2013. Milk production, fatty acid composition and vitamin E content of Payoya goats according to grazing level in summer on Mediterranean shrublands. *Small Ruminant Research* 114, 167-175.

Emami, A., Fathi-Nasri, M.H., Ganjkhanlou, M., Rashidi, L., Zali, A., 2016. Effect of pomegranate seed oil as a source of conjugated linolenic acid on performance and milk fatty acid profile of dairy goats. *Livestock Science* 193, 1-7.

FAOSTAT, 2019a. Available at http://www.fao.org/faostat/en/#data/QA [29 Septamber. 2019].

FAOSTAT, 2019b. Available at http://www.fao.org/faostat/en/#data/QL [29 Septamber. 2019].

Fernandez, F.J., Vazquez, H.C., Castillo-Juarez, H., Saltijeral-Oaxaca, J.A., Gonzalez-Montana, J.R., Fernandez, M., 2008. Somatic cell counts and quality of goat milk produced in the central region of Mexico. *Research Journal of Dairy Science* 2, 45-50.

Gaddour, A., Najari, S., Ferchichi, A., 2009. Lactation curve of local goat, pure breeds and crosses in Southern Tunisia. *Journal of Applied Animal Research* 36, 153-157.

Gooki, F.G., Mohammadabadi, M., Fozi, M.A., Soflaei, M., 2019. Association of biometric traits with growth hormone gene diversity in Raini Cashmere goats. *Walailak Journal of Science and Technology* 16, 499-508.

Güzeler, N., Say, D., Kaçar, A. 2010. Compositional changes of Saanen×Kilis goats' milk during lactation. *Gida* 35, 325-330.

Hoseini, S.M., Ghazikhani, A., Kalantar, M., 2011. Comparison the genetic potential of some growth & milk traits of hybrid crossed Saanen with native Goat Lori Black goat versus native goats in Qom province. *Journal of Agricultural Science and Technology* 1, 1297-1299.

Hosseini, S.M., Yang, L.G., Abbas-Raza, S.H., Khan, R., Kalantar, M., Syed, S.F., Kakar, M.U., Manzoor, R., 2017. Comparison of weight gain, milk production, and milk composition of Iranian Mamasani goat and its cross with Saanen. *Journal of Veterinary Science & Animal Husbandry* 5, 1-3.

Ishag, I.A., Abdalla, S.A., Ahmad, M.K.A., 2012. Factors affecting milk production traits of Saanen goat raised under Sudan-semi arid conditions. *Online Journal of Animal and Feed Research* 1, 435-438.

Jaafar, S.H.S., Hashim, R., Hassan, Z., Arifin, N., 2018. A comparative study on physicochemical characteristics of raw goat milk collected from different farms in Malaysia. *Tropical Life Sciences Research* 29, 195-212.

Katanos, J., Skapetas, B., Laga, V., 2005. Machine milking ability and milk composition of some imported dairy goat breeds and some crosses in Greece. *Czech Journal of Animal Science* 50, 394-401.

Klir, Z., Potocnik, K., Antunovoc, Z., Nnovoselec, J., Barac, Z., Mulc, D., Kompan, D., 2015. Milk production traits from Alpine breed of goats of in Croatia and Slovenia. *Bulgarian Journal of Agricultural Science* 21, 1064-1068.

Landau, S., Vecht, J., Perevolotsky, A., 1993. Effects of two levels of concentrate supplementation on milk production of dairy goats browsing Mediterranean scrubland. *Small Ruminant Research* 11, 227-237.

Margatho, G., Rodiguez-Estevez, V., Medeiros L., Simoes, J., 2018. Seasonal variation of Serrana goat milk contents in mountain grazing system for cheese manufacture. *Revue de Médecine Vétérinaire* 169, 166-172.

Mioč, B., Prpić, Z., Vnučec, I., Barać, Z., Sušić, V., Samaržija, D., Pavić, V., 2008. Factors affecting goat milk yield and composition. *Mljekarstvo* 58, 305-313.

Ogola, T.D.O., Kosgey, I.S., 2012. Breeding and development of dairy goats: eastern Africa experience. *Livestock Research for Rural Development 24. Available at* http://www.lrrd.org/lrrd24/1/ogol24021.htm [Verified 25 November 2019].

Park, Y., Pariza, M.W., 2007. Mechanisms of body fat modulation by conjugated linoleic acid (CLA). *Food Research International* 40, 311-323.

Park, Y.W., Juarez, M., Ramos, M., Haenlein, G.F.W., 2007. Physico-chemical characteristics of goat and sheep milk. *Small Ruminant Research* 68, 88-113.

Pollott, G., Wilson, R.T., 2009. Sheep and goats for diverse products and profits. 9th Diversification booklet, Food and Agriculture Organization of the United Nations, Rome.

Prasad, H., Tewari, H.A., Sengar, O.P.S., 2005. Milk yield and composition of the Beetal breed and their crosses with Jamunapari, Barbari and Black Bengal breeds of goat. *Small Ruminant Research* 58, 195-199.

Rodríguez-Alcalá, L.M., Harte, F., Fontecha, J., 2009. Fatty acid profile and CLA isomers content of cow, ewe and goat milk processed by high pressure homogenization. *Innovative Food Science and Emerging Technologies* 10, 32-36.

SAS. 2004. SAS Procedures Guide Release 9.1. SAS Inst Inc, Cary, North Carolina, USA.

Sedighi-Vesagh, R., Naserian, A.A., Ghaffari, M.H., Petit, H.V., 2015. Effects of pistachio by-products on digestibility, milk production, milk fatty acid profile and blood metabolites in Saanen dairy goats. *Journal of Animal Physiology and Animal Nutrition* 99, 777-787.

Serradilla J.M. 2001. Use of high yielding goat breeds for milk production. *Livestock Production Science* 71, 59-73.

Shelton M. 1986. Breed use and crossbreeding in goat production. 3rd World Congress on Genetics Applied to Livestock Production, Nebraska, USA.

Simopoulos, A., 2008. The importance of the omega-6/omega-3 fatty acid ratio in cardiovascular disease and other chronic diseases. *Experimental Biology and Medicine* 233, 674-688.

Strzałkowska, N., Jóźwik, A., Bagnicka, E., Krzyżewski, J., Horbańczuk, K., Pyzel, B., Horbańczuk, J.O., 2009. Chemical composition, physical traits and fatty acid profile of goat milk as related to the stage of lactation. *Animal Science Papers and Reports* 27, 311-320.

Suranindyah, Y.Y., Khairy, D.H.A., Firdaus, N., 2018. Milk production and composition of Etqwah crossbred, Sapera and Saperong dairy goats in Yogyakarta, Indonesia. *International Journal of Dairy Science* 13, 1-6.

Talpur, F.N., Bhanger, M.I., Memon, N.N., 2009. Milk fatty acid composition of indigenous goat and ewe breeds from Sindh, Pakistan. *Journal of Food Composition and Analysis* 22, 59-64.

Tsiplakou, E., Kotrotsios, V., Hadjigeorgiou, I., Zervas, G., 2010. Differences in sheep and goats milk fatty acid profile between conventional and organic farming systems. *Journal of Dairy Research* 77, 343-349.

Tudisco, R., Cutrignelli, M.I., Calabrò, S., Piccolo, G., Bovera, F., Guglielmelli, A., Moniello, G, Infascelli, F., 2010. Influence of organic systems on milk fatty acid profile and CLA in goats. *Small Ruminant Research* 88, 151-155.

Wanjekeche, E., Macosore, Z., Kiptanui, A., Lobeta, T., 2016. Quality and consumer acceptability of goat breed and lactation stage. *African Crop Science Journal* 24, 95-99.

Yurchenko, S., Sats, A., Tatar, V., Kaart, T., Mootse, H., Jõudu, I., 2018. Fatty acid profile of milk from Saanen and Swedish Landrace goats. *Food Chemistry* 254, 326-332.

Zervas, G., Tsiplakou, E., 2011. The effect of feeding systems on the characteristics of products from small ruminants. *Small Ruminant Research* 101, 140-149.