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Physicochemical Characteristics of Milk and Teat Yield of Different Goat Breeds Under Normal Tropical Rearing Conditions

(KARAKTER FISIKOKIMIA SUSU DAN PRODUK PUTING BERBAGAI RAS KAMBING YANG DIPELIHARA DALAM SUASANA TROPIS NORMAL DI FILIPINA)

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ABSTRACT

The use of imported high-yielding exotic breeds of goats under sub-optimal conditions either as a substitute to less productive local breeds or for upgrading puposes is not new. However, there is a need to enhance the production potential of these goats given the existing management practices and feeding conditions in order to realize their full economic impact. Using 41 clinically healthy lactating goats from seven different breeds including upgrades, and collected every week for eight consecutive weeks, our study demonstrates how these exotic breeds perform under normal tropical rearing conditions in terms of physicochemical characteristics of milk and teat yield. For the milk yield, Saanen (397.8 ± 40.1 mL), Toggenburg (310.2 ± 28.6 mL) along with Alpine (297.1 ± 27.9 mL) topped all the breeds while the lowest was in upgrades (178.8 ± 7.8 mL; $P < 0.05$). There were no significant differences in the physicochemical characteristics of milk between the left and right udder halves except where pH was higher and calcium was lower in the left udder half ($P < 0.05$), respectively. Similarly, results show that both milk labeled as 'good' and 'bad' had relatively similar values for solids-not-fat, calcium, phosphorus, and density ($P > 0.05$) except for pH and fat content which were higher in milk samples labelled as 'bad' ($P < 0.05$). Such information could be useful to prospecting goat farmers especially for those in the goat milk processing industry.

Keywords: goat milk, physicochemical characteristics, teat yield, Philippines

ABSTRAK

Pemanfaatan kambing-kambing ras eksotik impor yang memiliki produksi tinggi di bawah suasana suboptimal, bukanlah hal yang baru. Walaupun demikian, adalah perlu didorong potensi produksi kambing-kambing tersebut dengan memberikan praktek pengelolaan seperti apa yang telah berlangsung selama ini dalam upaya memberikan dampak ekonomi secara penuh. Penelitian ini menggunakan kambing induk yang secara klinik sehat dan sedang menyusui. Sebanyak 41 ekor kambing menyusui dari tujuh ras berbeda termasuk kambing yang diupgrade, dikoleksi contoh susunya setiap minggu, selama delapan minggu secara berurutan. Kambing-kambing ras eksotik ini, yang dipelihara dalam suasana tropis normal , menunjukkan performa mereka dalam peubah karakteristik fisikokimia susu dan produksi putingnya. Untuk produksi susu, kambing ras saanen memproduksi 397, 8 ± 40,1 mL, kambing toggenburg 310,2 ± 28,6 mL, kambing alpine 297,1 ± 27,9 mL. Ketiga kambing-kambing tersebut merupakan penghasil susu yang paling tinggi, sedangkan kambing yang paling rendah produksi susunya adalah kambing upgrading dengan produsi sebanyak 178,8 ± 7,8 mL ($P<0,05$). Dalam penelitian ini tidak ditemukan adanya perbedaan yang bermakna dalam karakteristik fisikokimia susu kambing, antara ambing sisi kiri dengan ambing sisi kanan, kecuali dalam hal pH yang lebih tinggi, dan kadar kalsium yang lebih rendah pada ambing sisi kiri ($P<0,05$). Begitu pula hasil penelitian menunjukkan bahwa susu yang dilabel 'baik' maupun 'buruk', secara relatif memiliki nilai yang mirip dalam hal padatan bukan lemak, kalsium, dan posfor ($P>0,05$), kecuali untuk pH dan kandungan lemak yang ternyata lebih tinggi pada sampel susu yang dilabel 'buruk' (P<0,05). Informasi ini diharapkan dapat bermanfaat dan memberi harapan bagi para peternak kambing khususnya peternak kambing yang berkecimpung dalam industri pemrosesan susu kambing.

Kata-kata kunci: susu kambing; karakter fisikokimia; produksi puting; Filipina

INTRODUCTION

Goat milk production and processing is a dynamic and growing industry worldwide which contributes significantly to the economy of many countries (Park, 2010; Ulusoy, 2015). This resulted in the expansion of goat farming given the ability of goats to provide high quality food under diverse climatic conditions and being able to thrive in vegetation that does not necessarily compete with human nutrition (Devendra and Burns, 1970; Silanikove *et al*., 2010; Norris *et al*., 2011). However, despite the ever-growing demand for goat meat and milk, goat production in the Philippines still falls behind among the country's livestock production with only about 3.76 million heads in early 2019 (PSA, 2019). While most of the goat population is raised in Central Visayas (Region 7; 13.81%), the Eastern Visayas (Region 8) records the lowest goat inventory in the country at only 1.07%. Consequently, this is reflected by the very low average *per capita* consumption for chevon and fresh/pasteurized milk in Eastern Visayas to as little as 0.01kg and 0.05 liter, respectively (PSA, 2017). The country's national goat science and technology initiatives were drawn specifically to fill in the gap and aimed to promote and enhance goat production in the country. Among these programs include improving conception rates from 75% to 90% by 2020, shortening kidding interval, decreasing preweaning mortalities, and enhancing slaughter standards among others (Alo, 2017).

On a similar scale, there is more to be done with the country's milk production. While the 4% growth in the local milk production in 2018 is a positive sign to address the local demand for ready to drink milk (RTD), local milk production only accounts for about one glass in every four glasses of liquid milk supply (NDA, 2018). Dairy cattle (62%) and carabao (35%) contributed significantly to the total volume of milk produced but unfortunately, goat's milk is still way below at only 3% (NDA, 2018). Several government institutions including the National Dairy Goat Science and Technology, the National Dairy Authority, universities and other government-subsidized goat stations spread over the country were put in place to improve and enhance goat production targets to complement milk production and alleviate undernutrition and malnutrition.

The demand for goat continues to grow as reflected by the almost 10% increase in gross value of goat production in 2018 than in 2017 (PSA, 2019). Moreover, goat's milk is particularly attractive to certain consumers due to its beneficial effects against gastrointestinal disturbances, allergy and lactose intolerance (Haenlein, 2004; Yadav *et al*., 2016). It was noted that goat's milk contains 25% more Vitamin B6, 47% more Vitamin A and 13% more calcium than cow's milk (Getaneh *et al*., 2016) and is a prolific source of other macro- and micronutrients. Moreover, pasteurized goat's milk and processed cheese cost more than cow's milk thus offering better market opportunities (Ulusoy, 2015).

Milk production in goats can be affected by a number of factors including genetic type, age, lactation stage, parity, management, climatic factors as well as the method of milking (de Souza *et al*., 2014; Idowu and Adewumi, 2017; Lôbo *et al*., 2017). Moreover, the production potential from exotic, local and crossbred goats could vary significantly due to strong differences of management and environmental conditions these goats were used to (Serradilla, 2001; Idamokoro *et al*., 2017). Thus, among the basic strategies of the government is to conduct an inventory of goat stocks available and examine the performance of these goats which will be useful for designing management strategies.

One of the notable goat stations in Eastern Visayas is the Malitbog Goat Center in Malitbog, Southern Leyte which was mandated not only to train prospective goat farmers but also to serve as a pool of good quality stocks of goats and develop them for the region. Some breeds of goats that are maintained in the center include Alpine, Saanen, Anglo-Nubian, Anglo-Nubian-Crossbred, Toggenburg, Oberhasli, and local upgrades. This study therefore is an attempt to evaluate the milk yield and quality characteristics from different imported goat breeds under normal rearing conditions. This will establish baseline information useful for breed selection, improving current management practices, crossbreeding strategies as well as marketing decisions and opportunities. Moreover, the physicochemical characteristics of goat's milk determined in this study could provide technical information not only on the milk's potential health benefits (Faye, 2016) but also milk processing and marketing requirements.

RESEARCH METHODS

Location of the study

The study was conducted at the Malitbog Goat Center, Sangahon, Malitbog, Southern Leyte, Philippines, one of the focal regional goat stations in Eastern Visayas (10°10'44.9"N, 124°57'38.4"E). The center is about 10.5 hectares equipped with production and research facilities as well as road networks. It has a dedicated pasture area for growing different pasture grass and legume species.

Animal sampling and management

Forty-one clinically healthy goats distributed across seven different breeds: Alpine, Saanen, Anglo-Nubian, Anglo-Nubian-Crossbred, Toggenburg, Oberhasli, and upgrades were randomly selected and confined in separate groups inside an elevated goat house with wooden slatted floors. To qualify for the study, only goats that were at least two years old, had at least one parity, a body condition score between 2.5-4.0 and completed kidding within the first 2-month window were selected. Goats were managed and fed following standard rearing practices at the center using a mixture of grasses (40%) and legumes (60%). This was made possible *via* a V-shaped feedthrough with vertical slats placed at the center of the pens. High-protein concentrates (CP, 16%; ME, min 2800 kcal/kg; Calcium, 0.75%; Phosphorus, 0.65%; Pigrolac Vital Grower Pellets, UNAHCO) was also provided at 250 g/hd/day. The goats have access to water at all times made from plastic drum containers cut in half and filled regularly *via* a water faucet near the entrance of the pens.

Milk collection and quality determination

Milks samples for evaluation were collected every Wednesday of the week for eight consecutive weeks between February and March 2019. Collection was done in the morning (07.00-10.00) as normally practiced in the center (Figure 1). Initially, the samples were evaluated using a modified Whiteside test as indirect screening for mastitis (Whiteside, 1939). Briefly, one mL of diluted NaOH solution (0.40 mL NaOH plus 9.60 mL distilled water) was added into three mL of milk in a clean, flat, small plastic pan and shaken gently. The formation of viscid mass would mean that the milk sample was collected from a suspected mastitic udder and is labelled as 'bad' milk. The absence of coagulates means that the milk passed the initial screening and labelled as 'good'. Total milk volume from each udder halves was determined using a glass graduated beaker.

Determination of physicochemical characteristics of milk

Milk from each udder (100 mL each) was divided into two 50-mL samples and placed individually in clean plastic containers. The containers were labeled accordingly, stored inside an insulated box filled with ice and transported to the laboratory overnight for physicochemical analysis (Figure 2).

Figure 1. Milk collection in an Alpine x Anglo-Nubian goat at Malitbog Goat Center using a dedicated collection crate.

Figure 2. Individually labeled containers with milk samples ready for transport.

Milk samples were processed and analyzed at the milk processing and analysis laboratory of Norient Fresh at Dumaguete City, Negros Oriental using Lactoscan SL Milk Analyzer (Sri Balaji Instruments, India). Among the milk parameters measured include the levels of fat, solids-not-fat, lactose, calcium, phosphorus, and density. An automated pH meter (Hanna pH tester Model # HI98107P, Hanna Equipment, United States) was used to determine the milk pH.

Data analysis

Data were analyzed using the IBM SPSS® statistics platform (IBM Corporation, United States). Standard procedures were initially conducted to determine normality in the distribution (Shapiro-Wilk test) and variance (Levene's test) of the data for appropriate statistical analysis. The Mann-Whitney U test was used to determine differences in milk parameters between the left and the right teat as well as between 'good' and 'bad' milk. Kruskal-Wallis test was used to determine if there were significant differences in different milk parameters between goat breeds. Where the result is significant, a separate pairwise comparison was carried out to determine significant differences for each parameter tested between breed. The level of significant difference was set at $P \leq 0.05$.

RESULTS AND DISCUSSION

Results

The physicochemical composition of milk along with the milk yield between different breeds are presented in Figure 3 and Table 1, respectively. For the milk yield, Saanen (397.8 ± 40.1 mL), Toggenburg (310.2 ± 28.6 mL) along with Alpine (297.1 ± 27.9 mL) topped all the breeds while the lowest was in upgrades (178.8 ± 7.8 mL; $P < 0.05$).

Solids-not-fat was relatively similar among different goat breeds except it was lowest in Toggenburg (6.3±0.0%). Interestingly, calcium was highest with Oberhasli and Toggenburg at 4.2 ± 0.0% although all breeds were at least at 4% calcium level. The Upgrades has the highest fat (5.7 ± 0.4%; $P < 0.05$), and lactose content along with the Anglo-Nubian Purebred (4.1 ± 0.0%). The pH was fairly neutral although only the Alpine breed has reached pH of 7.0 ±0.9.

Results also showed that milk from the right and left udder halves have similar lactose, density, fat, solids-not-fat, and phosphorus (Table 2; $P > 0.05$). Overall, there was no significant difference in the physicochemical characteristics between both left and right udder halves except where pH was higher, and calcium was lower in the left udder half ($P < 0.05$), respectively.

The difference in physicochemical composition between 'good' and 'bad' milk is presented in Table 3. Similarly, the results show that both milk labelled as 'good' and 'bad' had relatively similar values for solids-not-fat, calcium, phosphorus, and density ($P > 0.05$) except for pH and fat content that were higher in milk samples labelled as 'bad' ($P < 0.05$).

Discussion

The use of imported high-yielding exotic breeds of goats under suboptimal conditions either as a substitute to less productive local breeds or for upgrading purposes is not new (Serradilla, 2001). While, it is not surprising that exotic breeds tend to perform better in their regions of origin (Devendra, 1972; Serradilla, 2001), there is a need to enhance the production potential of these goats when imported to different conditions. Our study provides notable information on how these exotic breeds perform under normal tropical rearing conditions. Hence, such information could be useful to prospecting goat farmers especially for those in the goat milk processing industry.

Generally, tropical breeds have lower milk yield due to their lower genetic potential and prevailing environmental factors than their temperate counterparts (Devendra and Burns, 1970; Devendra, 1972; Lôbo *et al.*, 2017). Although certain species-specific differences exist, the major nutrient composition, flavor, and appearance of goat milk is similar with cow's milk (Park, 2010, 2017). Similarly with cow's milk, the nutritive composition of goat's milk varies greatly due to genetic and non-genetic influences (Idowu and Adewumi, 2017) including: diet, breed, individuals, parity, weather, feeding, management, environment conditions, locality, stage of lactation, rearing conditions (Iloeje and Van Vleck, 1978), and health status of the udder (Bianchi *et al.*, 2004) among others (Cak *et al.*, 2017; Jaafar *et al.*, 2018). However, some pathogens in the milk and high somatic cell count (SCC) may also affect yield and alter the milk's physicochemical composition (Coulona *et al*., 2002; Haenlein, 2002), although, the degree of change depends on what mastitis-causing pathogen is present (dos Reis *et al*., 2013).

Our current study demonstrated that Saanen, one of the most prominent dairy goat breeds still performed better in tropical condition and outperformed the other breeds. While our current teat yield data for Saanen could be lower than the average daily production output by the Saanen breed, this could be due to possible heat stress encountered by goats in tropical environment conditions. This could inevitably lead to lower feed consumption (Lu, 1989) while also affecting rumination (Hirayama *et al*., 2004). Similar results were reported in Malaysia (Khandoker *et al*., 2018) showing good performance of Saanen breed despite of tropical conditions. In such a case, the Saanen breed could be a good choice and prospecting goat farmers would need to strategize ways to further improve the performance of Saanen to be able to adapt better to their existing conditions and management practices.

Our study also showed good milk yield from the Toggenburg, Alpine and Anglo-Nubian breeds while the lowest was in upgrades. These differences in the milk yield could be

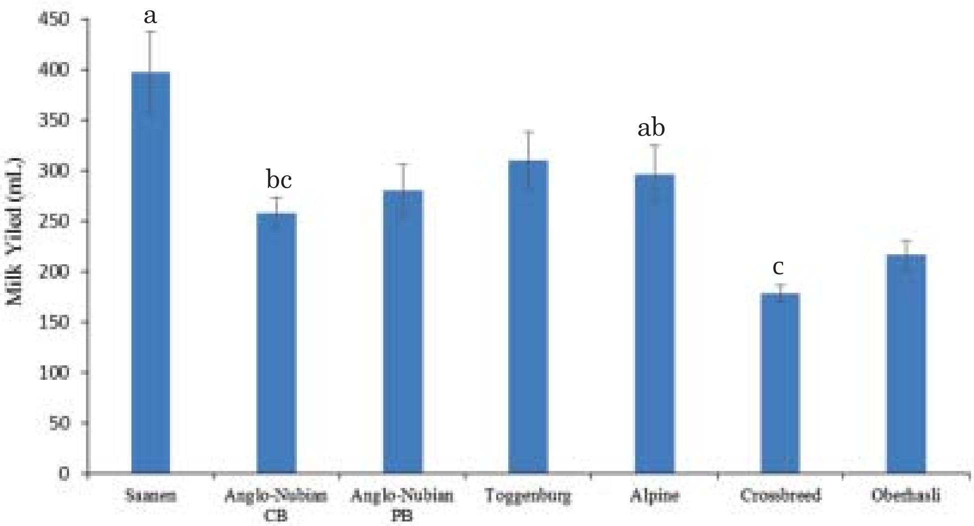

Figure 3. Mean (± SEM) milk yield (mL) from different goat breeds from eight weekly consecutive collections for both the left and right udders. Differet letters indicate a significant difference between breeds (P ≤ 0.05). CB - Crossbred; PB - Purebred

Table 1. Mean (±SEM) values for yield and physicochemical composition of milk from different goat breeds.

Breed	Physicochemical composition					
	SNF (%)	Ca (%)	P(%)	Fat (%)	pH	Lactose(%)
Anglo-Nubian Purebred	7.2 ± 0.0^{a}	4.0 ± 0.0^{b}	2.4 ± 0.0^{b}	4.7 ± 0.1^{c}	6.2 ± 0.0^{bd}	4.1 ± 0.0^{ae}
Toggenburg	6.3 ± 0.0^{c}	4.2 ± 0.0^{c}	2.2 ± 0.0^{d}	2.7 ± 0.1^{d}	6.1 ± 0.0^{b}	3.4 ± 0.0^{c}
Anglo-Nubian Crossbred	6.8 ± 0.0^{b}	4.1 ± 0.0^{a}	2.3 ± 0.0^{c}	4.1 ± 0.1^{b}	6.2 ± 0.0^{b}	3.9 ± 0.0^{ab}
Alpine	6.9 ± 0.0^{b}	4.0 ± 0.0^{a}	2.3 ± 0.0^{bc}	3.6 ± 0.3^{d}	7.0 ± 0.9^{d}	3.8 ± 0.0^{d}
Oberhasli	6.5 ± 0.0^{d}	4.2 ± 0.0^{bc}	2.1 ± 0.0^{d}	3.7 ± 0.1^{a}	6.1 ± 0.1^{bcd}	3.6 ± 0.0^{f}
Upgrades	7.2 ± 0.1^{a}	4.0 ± 0.0^{d}	2.4 ± 0.0^{b}	5.7 ± 0.4^{e}	6.3 ± 0.0^{ac}	4.1 ± 0.0^{ae}
Saanen	7.2 ± 0.0^{a}	4.1 ± 0.0^{a}	2.4 ± 0.0^{a}	3.7 ± 0.0^{ab}	6.5 ± 0.0^{a}	4.0 ± 0.0^{abde}

SNF, Solids-not-fat; Ca, calcium; P, Protein; Differet letters indicate a significant difference between breeds (P ≤ 0.05).

Table 2. Mean (±SEM) values for physicochemical composition of milk collected from the left and the right udder halves.

Udder	n	Parameters						
		Lactose(%)	pH	Density(kg/m³)	Fat(%)	SNF(%)	Ca(%)	P(%)
Left	393	3.8±0.0	6.4±0.1[a]	22.5±0.1	3.9±0.1	6.8±0.0	4.1±0.0[b]	2.3±0.0
Right	425	3.8+0.0	6.2±0.0[b]	22.7±0.1	3.8±0.1	6.8±0.0	5.0±0.9[a]	2.3±0.0

SNF - Solids-not-fat, Ca – Calcium, P – Phosphorus; Differet letters indicate a significant difference between the left and right udder halves ($P \leq 0.05$).

Table 3. Mean (±SEM) values for physicochemical composition of milk labelled as good or bad.

Milk Quality	n	Parameters						
		Lactose(%)	pH	Density(kg/m³)	Fat(5)	SNF(%)	Ca(%)	P(%)
Good	445	3.8 ± 0.0	6.2 ± 0.0[b]	22.8 ± 0.0	3.8 ± 0.0[b]	6.8 ± 0.0	4.1 ± 0.0	2.3 ± 0.0
Bad	332	3.9 ± 0.0	6.3 ± 0.1[a]	22.7 ± 0.1	4.3 ± 0.0[a]	6.8 ± 0.0	4.1 ± 0.0	2.3 ± 0.0

SNF - Solids-not-fat, Ca – Calcium, P – Phosphorus; Differet letters indicate a significant difference between 'good' and 'bad' milk ($P \leq 0.05$).

attributed to the diet, as well as other genetic and environmental factors as mentioned earlier. Due to logistical reasons and since the focus of this study was on the physicochemical composition of the milk, we didn't consider an ideally longer lactation yield. Therefore, the eight-week collection time in relation to the milk yield reported in this study may not be enough to warrant the potential average daily milk yield. While these four breeds: Saanen, Toggenburg, Alpine and Anglo-Nubian Purebred performed well in our study in terms of milk yield, a study in Trinidad recommends Anglo-Nubian as a better breed in tropical humid environment for their ability to adapt better against high temperature, along with its prolificacy (Lallo *et al.*, 2012). Anglo-Nubian has been considered a robust and high-yielding breed with good heritability of total milk yield and daily milk yield in the Philippine setting (Bondoc *et al.*, 2018) which can be exploited for selection programs. Thus, our study also shows higher milk yield in the Anglo-Nubian crossbred similar to what was reported earlier (Ruvuna *et al.*, 1995).

Milk production depends heavily on the amount of nutrients the animal consumed. Lactating goats require specific protein and energy level and these have to be carefully considered when formulating rations for lactating does (Nsalahlai *et al.*, 2004; Sahlu *et al.*, 2004). The center uses concentrates to supplement these nutrient requirements, however, since these concentrates are particularly formulated for pigs, specific requirements for lactating goats need to be considered. Nutrition can significantly affect both the yield and composition of the milk (Chilliard *et al.*, 2007; Morand-Fehr *et al.*, 2007; Looper, 2012). Both genetic and non-genetic factors may impact the level of milk production as well as its characteristics (Idowu *et al.*, 2017).

The other important factor that affects milk yield and composition is the stage of lactation either early, mid, or late lactation. According to El-Tarabany *et al.* (2018), the average milk yield in Baladi goats peaks during the early stage of lactation and steadily declines thereafter until the late stage of lactation. Likewise, milk composition varies in accordance with the lactation stages. Goat milk composition, especially fat and protein are high in colostrum in early lactation and much lower thereafter, then increasing once again when the yield is low by the end of lactation period (Aganga *et al.*, 2002; Idamokoro *et al.*, 2017).

Udder differences in yield and composition of milk have been reported in some species. For example, milk yield, proteins, fat and calcium concentrations were found higher in milk collected from rear udders of camels (*Camelus dromedarius*; Eisa and Hassabo, 2009), while the right breast is said to produce more milk in lactating women (Engstrom *et al.*, 2007).

Interestingly, our study found calcium and pH to be higher and lower in the right udder, respectively. The center normally conducts preliminary screening for milk quality between the left and the right teat. This is in relation to studies showing interdependence in the distribution of mastitis and intra-mammary infection among udders (Barkema *et al*., 1997; Berry and Meaney, 2006; Bharti *et al*., 2017) particularly in the hind and right side quarter in the cows (Bharti *et al*., 2017). The center routinely determines milk quality on-site through Whiteside test (WST), an indirect screening test for mastitis as indicated by the formation of viscid mass in mastitis-infected milk (Whiteside, 1939). The presence of leucocytes is responsible for the formation of the precipitates in the test, and calcium chloride disperses these precipitates to form small clumps (Nageswararao and Derbyshire, 1970). Only those milk labeled as 'good' are processed for human consumption, while those labeled as 'bad' milk are discarded from processing and are given to kids or processed to form soap. In this study, both the 'good' and the 'bad' milk were analyzed for its physicochemical characteristics.

For milk regardless of the udder source labelled as 'good' or 'bad', both pH and fat appeared to be higher in 'bad' milk. Nevertheless, pH of goat milk reported in this study ranges between 6.2-6.5 and was similar with earlier report (Fandialan *et al*., 2001). An increased pH has been observed in milk with subclinical mastitis which can be associated with tissue damage (Batavani *et al*., 2007) and this could affect the heat stability of milk during processing (Huppertz, 2016). On the contrary, milk fat has been reported to be lower in infected than those in the uninfected udder halves as seen in dairy sheep with subclinical mastitis infection (Leitner *et al*., 2004). While the average milk fat for goat milk is about 3.8% (Park, 2010; 2017), our study found a higher milk fat in upgrades (5.7±0.4%) while lowest in Toggenburg, similar to the study of Norris *et al*. (2011) when raised in extensive system. Nevertheless, low fat concentration was also reported when the animal is reared tropical regions (Mayer and Fiechter, 2012).

Lactose concentrations in our study appeared to belower than the reported average which is 4.6% (Park ,2010). This low concentration is said to be generally observed with imported goat breeds in tropical conditions (Devendra, 1972). Lactose is a valuable nutrient, because it favors intestinal absorption of calcium, magnesium, and phosphorus and the utilization of vitamin D. Moreover, given the relatively lower solids-not-fat (SNF) percentages reported in this study, several improvements may be needed to increase the energy content of the diet. In cattle, improving the amount of feed consumed before and after parturition may improve the levels of fat and SNF in milk (Khan *et al*., 2004).

CONCLUSION

In conclusion, our study demonstrated interesting differences in teat yield as well as the physicochemical characteristics of milk from different goat breeds under normal tropical rearing conditions. Our goal is for potential and prospecting goat farmers to find the results reported in this study as useful for breed selection and management. The empirical results on the physicochemical composition of milk could be especially beneficial to those involved in the goat milk processing industry.

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Conflict of Interest

The authors declare no conflict of interest.

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