Spiteri R and Attard E, J Dairy Res Tech 2019, 2: 006
DOI: 10.24966/DRT-9315/100006

HSOA Journal of
Dairy Research & Technology

Research Article

Determination of Physico-chemical Characteristics of Maltese Ovine, Caprine and Bovine Milk

Ritiannne Spiteri[1,2] and Everaldo Attard[1,2*]

[1]*Veterinary and Phytosanitary Regulation Division, Veterinary Regulation, Ministry for the Environment, Sustainable Development and Climate Change, Abattoir Street, Albert Town, Marsa, Malta*

[2]*Division of Rural Sciences and Food Systems, Institute of Earth Systems, University of Malta, Msida MSD 2080, Malta*

Abstract

The identification of raw milk characteristics is a fundamental step towards the valorization of dairy products. The aim of this study was to evaluate the physicochemical characteristics of bovine, ovine and caprine milk, in Malta and Gozo, to define interspecies differences and determine possible differences between the two islands. 220 pooled milk samples were collected from farms in Malta and Gozo and analyzed for proximate parameters, using the Master Pro milk analyzer. This study revealed minor differences in milk physicochemical characteristics between farms in Malta and Gozo however interspecies differences were significant ($p<0.05$). Statistical analysis revealed that ovine milk was highest in fats (6.56±1.72 %), solids-non-fat (10.47±0.69%), proteins (3.79±0.26%), lactose (5.65±0.37%) and salts (0.81±0.07 %) and had the lowest freezing point (-0.73±0.09°C). Principal component analysis revealed correlations ($r>0.974$) between proteins, lactose, solids-non-fat and salts demonstrating that these variables are directly proportional with each other but are inversely proportional to the freezing point ($r<-0.941$). Principal component analysis also displayed distinctive characteristics for ovine milk. Due to the distinctive interspecies differences, this study may serve as a basis to distinguish the milk types by their physicochemical constitution. Subsequently, the traceability of the milk type can be achieved on this basis.

Keywords: Cow; Dairy; Goat; Milk; Proximate analysis; Sheep

***Corresponding author:** Everaldo Attard, Division of Rural Sciences and Food Systems, Institute of Earth Systems, University of Malta, Msida MSD 2080, Malta, everaldo.attard@um.edu.mt

Citation: Spiteri R, Attard E (2019) Determination of Physicochemical Characteristics of Maltese Ovine, Caprine and Bovine Milk. J Dairy Res Tech 2: 006.

Received: July 21, 2019; **Accepted:** August 13, 2019; **Published:** August 20, 2019

Introduction

Dairy farms are distributed all around the Maltese Islands. According to the Veterinary Regulation Directorate [1], in November 2014 there were approximately 85 dairy bovine farms and approximately 1339 farms involving ovine and caprine in Malta, and there were approximately 35 dairy bovine farms and approximately 561 farms involving ovine and caprine in Gozo. Producers may rear more than one type of species on the same farm and others may not have lactating females on farm hence the approximate amount of dairy herds in Malta and Gozo (in November 2014) was 1800. The most commonly bred dairy cattle breeds include the *Holstein-Friesian*, the *Jersey*, the *Brown Swiss* and the *Estonian Red Cattle* breeds. Caprine breeds include the *Alpine*, the *Girgentana*, the *Saanen* and the *Maltese* while ovine breeds include the *Comisana*, the East Friesian, the Maltese and the *Cross-Breed* [2].

A dairy bovine can live for more than ten years; however the first three lactating periods are the most productive. For a bovine to produce milk, it has to be bred and produce calves. A dairy bovine is able to produce from 6,800kg to 17,000kg of milk per lactation; however this amount depends on several factors that influence milk yield mainly: breed, lactation stage, parity, season, stress and physical health [3]. The most common type of milking regime of a dairy bovine is twice daily however there are producers who carry out a three time milking regime daily. Studies have shown that sensitive breeders tend to reduce the milking frequency together with the feed allowance to reduce the physiological and metabolic stress after calving which is caused by the increase in milk yield after parturition [4]. This will in turn enhance immunity against common dairy bovine diseases and health problems and hence promote milk yield when the normal routine is readapted. Compared to the small ruminants, dairy cows produce higher yields and this is one of the main advantages of breeding bovine for milk. Ovine have always been among the most efficient livestock reared in Malta, producing effectively with a low amount of waste and excessive effort. Increased consumer demands for traditional dairy products such as the 'traditional Maltese cheeselet' [5] may potentially increase income for small-scale producers and also enhance opportunities in the dairy small ruminant industry. As in bovine, characterization of small ruminant milk also depends on several factors such as: reproduction, genetics, breeds, health status of animal, socio-economical environment and type of diet provided [6-9]. The majority of ovine milk is converted into cheese and hence optimum milk quality is essential to obtain high-quality distinctive cheeses. Some studies highlight the marked difference in ovine milk composition when compared to bovine and caprine milk [10]. Being small ruminants one of the main advantages of breeding caprine remains their ability to efficiently transform low quality forage into high quality products featuring unique organoleptic properties and distinctive chemical composition. Caprines are able to adapt to multiple climatic conditions and require less machinery to carry out milking procedures, with less demanding housing and general management. However, caprines produce much lower milk yields when compared to bovines. Undeniably, caprine milk and derived products are excellent food sources with outstanding qualities. Over the past 20 years, a new and growing interest in caprine milk and its products has occurred everywhere in the world. Popularity of caprine milk and associated products is continuously increasing especially in developed countries [11]. This is probably due to increased marketing of the therapeutic properties of caprine milk especially among persons who are allergic to bovine milk [12]. Although caprine milk does not differ significantly from the composition of bovine milk in terms of total solids, protein, fat and lactose, there is a marked difference in the structure, composition and size of casein micelles [10].

The main aim of this study is to evaluate the chemical characteristics of milk derived from bovine, ovine and caprine farms in Malta and Gozo and to determine any significant differences in milk between the two islands. This is a first study, on the islands, which is aimed to serve as a baseline picture for the quality of dairy milk and targets local authorities, producers and consumers.

Materials and Methods

Sampling

During 2013 and 2014, 220 milk samples were collected from dairy bovine and small ruminant farms in Malta and Gozo. The pooled samples were collected from the bulk tank or from the pail, depending on the farm's milking procedure. The aim of pooled samples collection rather than collecting samples from individual heads was to obtain an overview of the milk composition of Maltese and Gozitan farms. There were 30 farmers who provided more than one type of milk and this reduced the number of farms sampled to 190. There were 102 milk samples that derived from bovines, 89 derived from ovines and 29 derived from caprines. The samples were collected between October 2013 and March 2014 since during these months, small ruminants are lactating.

Sample preparation

Prior to analysis, samples that were left in the refrigerator from the day before were transferred to a water bath for approximately 30 minutes until they reached a temperature of approximately 30˚C. This procedure was not required for samples that were brought to the laboratory on the same day; however, samples that were sampled on the same date of testing were also put in the water bath for approximately 10 minutes so that all samples would have similar temperatures.

Milk analysis

The Master Pro milk analyser (Milkotester Ltd., Bulgaria) was used to determine the proximate profile of all collected milk samples. This equipment uses ultrasonic technology calibrated with wet chemical mehods used worldwide. Briefly, milk samples were allowed to acclimatizeand 50 ml aliquots were transferred to 100 ml beakers. The equipment was switched on, allowed to calibrate and then the milk type was selected on the display screen. After approximately 30 seconds, the equipment displayed the requested data on screen and the results were recorded. Data included temperature, fats, solids non fat, density, freezing point, protein, lactose, salts, added water, pH and conductivity.

Statistical analysis

The data concerning the bovine, ovine and caprine milk of the Maltese populations, were subjected to One-way analysis of Variance with the Bonferroni post-hoc test by using Prism v. 5 (GraphPad Software, Inc., USA) in order to determine differences in the proximate values for the species and locations interactions. Principal Component Analysis and Pearson correlations were conducted on all samples, using XLSTAT v.2014.4.04 (http://www.xlstat.com, Addinsoft) to determine any clustering for the species and locations. The significance level was considered at $p < 0.05$.

Results and Discussion

Milk is considered as one of the most important staple foods consumed by many populations worldwide. It is a suitable and complete food for children and particularly important for elderly and patients who cannot consume solid foods. Milk is converted into various dairy products primarily cheeses, yoghurts, butter, cream and ice cream. However, the nutritional value of milk and its suitable conversion into dairy products depend on the quality of milk. Nowadays milk from a number of mammals is sought after but the most common and traditional milk types consumed by humans remain the bovine, ovine and caprine milk. The physicochemical analysis for the bovine, ovine and caprine milk obtained from farms in Malta and Gozo, are illustrated in table 1.

Fat content

Milk fat content varies according to the type of milk produced by dairy plants including: whole milk, semi-skimmed milk and skimmed milk. Whole milk from bovine is usually marketed at the standard of 3.5% fat content [13,14]. Milk processing plants may modify the fat content to develop products according to consumer demands since milk fat is the most important component of milk in terms of cost, nutrition and sensorial characteristics. No significant difference in the mean percentage of fats in bovine, ovine and caprine milk was observed between the two islands ($p>0.41$). Interspecies differences were significant with ovine milk fat content (6.56±1.72%) being higher as compared to caprine and bovine (5.08±1.41% and 4.56±1.17%) milk fat content ($p<0.05$).

The milk fat in bovines in this present study was lower than the approximate 4.92% reported for a study on 134 dairy cows: Swedish red and white, Swedish Holstein and Danish Holstein-Frisian breed [15]. The latter is the main breed present in the Maltese Island showing higher milk fat content than the 3.26% and 3.62% obtained in two studies [16,17]. The milk in the latter study was used for the production of teleme cheese in Greece. The fat contents in this study were comparable to those reported on bulk tank milk deriving predominantly from Holstein-Friesian cows[18]. However for ovine milk in Tunisia, the fat content was higher for pasture, feedlot receiving hay and feedlot receiving silage (7.33%, 7.6% and 8.23%, respectively) [19]. Another study reported high fat content in ewe milk [20]. In a study conducted in Greece, fat content varied with seasonality, with an average mean of 6.79% and 7.6% for milk collected in spring and summer, respectively [21]. No significant difference between breeds was reported. With regards tocaprine milk, the same study reported an approximate value of 4.3% and 4.21% for milk in spring and summer, respectively which is lower than the average % for caprine milk obtained in this present study. Different milk fat percentages in ewes and goats may vary according to different stages of lactation [22]. In ewes, mean milk fat was 5.64%, 6.33% and 5.99% for early, middle and final stages of lactation respectively, which were all lower than the mean (6.56%), obtained in this present study.

	Bovine		Ovine		Caprine	
	Malta	**Gozo**	**Malta**	**Gozo**	**Malta**	**Gozo**
Temp °C	30±0	32±0	33±0	33±1	32±1	33±1
Fats % (w/v)	4.53±0.16	4.60±0.140	6.55±0.23	6.59±0.29	4.97±0.27	5.28±0.58
Solids Non Fat % (w/v)	7.75±0.03	7.70±0.03	10.57±0.08	10.23±0.15	8.15±0.09	8.13±0.32
Density kg/m3	26.9±0.3	26.9±0.2	32.0±0.3	30.9±0.5	28.5±0.3	27.8±0.7
Freezing point °C	-0.494±0.002	-0.491±0.002	-0.745±0.007	-0.717±0.012	-0.525±0.007	-0.529±0.027
Protein % (w/v)	2.79±0.01	2.77±0.02	3.83±0.03	3.70±0.06	2.93±0.03	2.93±0.12
Lactose % (w/v)	4.20±0.02	4.18±0.02	5.71±0.04	5.51±0.08	4.42±0.05	4.41±0.17
Salt % (w/v)	0.59±0.00	0.60±0.000	0.82±0.01	0.79±0.01	0.62±0.01	0.62±0.02
Added Water % (v/v)	0.3±0.1	0.2±0.2	0.0±0.0	0.0±0.0	0.0±0.0	0.9±0.7
pH	6.48±0.02	6.32±0.01	6.36±0.03	6.34±0.03	6.32±0.03	6.31±0.07
Conductivity mS/cm	4.6±0.0	4.8±0.0	4.7±0.0	4.8±0.0	4.5±0.0	4.6±0.0

Table 1: Comparison of the proximate characteristics between the milk of the three species in Malta and Gozo.Capital letters (A,B,C) are significant from NSM (*P<0.001*). Lower case letters (a,b.c) are significant among HCM or among LCM levels of separated milk (*P<0.001*).

With regards tocaprine milk, the authors reported mean milk fat 3.63%, 4.11% and 4.18% for early middle and final stage of lactation respectively, all of which were lower than the 5.08% obtained in this present study. Lower mean values for milk fat content for ovine and caprine milk (5.75% and 3.74%, respectively) were also reported in a study carried out in Austria [23]. Our results are somewhat comparable to those obtained in Portugal, showing that lambing affects milk composition with the mean fat increased from 5.97% to 7.05% [24]. The forage to concentrate ratio may also affect milk composition, with reported values of 6.77%, 6.23% fat in ovine milk [25], which is similar to what is reported in this present study. A high fat value is ideal for the production of cheeses. A study reported values of 7.60% and 5.10% for ovine and caprine milk, respectively [17], the latter being comparable with values obtained in this study. In another study carried out in France [26], different diets affected the fat content of caprine milk (3.0 - 3.31%), and which are much lower than the mean fat of 5.08% obtained in this study.

Solids non-fat content

The SnF portion in milk consists of protein (mainly casein and lactalbumin), carbohydrates (mainly lactose), and other minerals. Generally, the higher the fat content in the milk, the higher the SnF portion of the milk hence sustains ovine milk having a higher SnF content as compared to bovine and caprine milk. The mean concentration of SnF in bovine, ovine and caprine milk did not vary significantly between the two islands ($p>0.07$). Interspecies differences were significant with ovine milk SnF (10.50±0.69%) being relatively higher, followed by caprine (8.10±0.65%) then bovine (7.70±0.23%) milk SnF content ($p<0.05$).

In this study, SnF for ovine milk are similar to those (10.54%) obtained by Mayer and Fiechter [24]. Studies show that breed differences may not reflect significant differences in SnF content [21]. However, the authors observed interspecies differences in SnF (11.28% and 8.64%) for ovine and caprine milk, respectively. These were slightly higher than those obtained in this present study. Other studies reported higher (11.32% for ovine milk) [20] and lower (10.03% and 7.96%, ovine and caprine milk [23]. SnF values in the present study were comparable to those for Greek milk derived from ovine, caprine and bovine (11.65%, 9.05% and 8.89%, respectively) [17].

Protein content

The percentages of proteins in milk are approximately 3.2%, 3.4% and 6.2% for bovines, caprines and ovines, respectively [27]. However, this depends on several factors including breed and locality. In bovine and ovine, these proteins are mainly essential amino acids out of which approximately 80% is casein (αs1, αs2-, β- and κ-casein) [14,27]. The other milk proteins consist of whey or serum proteins such as α-lactalbumin, β-lactoglobulin, serum albumin, immunoglobulins, enzymes and enzyme inhibitors, metal (lactoferrin) and vitamin binding proteins, several growth factors, low molecular weight peptides (proteose-peptone) and bioactive peptides and all of these have important physiological properties [13,27]. The essential amino acids of caseins render milk as an important staple in the human diet primarily for the development and growth of the young while the other proteins play a vital role in nutrient transportation, disease resistance such as antibodies and other growth factors.

No significant differences were observed for protein content in bovine and caprine milk between Malta and Gozo ($p>0.28$); however a significant difference was observed between protein concentrations in ovine milk for the two localities ($p<0.05$) Interspecies differences were significant with ovine milk protein (3.79±0.26%) being relatively higher as compared to caprine and bovine (2.79±0.24% and 2.93±0.09%) milk protein content respectively ($p<0.05$).

In this study, results of protein content in bovine milk were lower than those reported on 134 dairy cows: Swedish red and white, Swedish Holstein and Danish Holstein-Frisian breed (4.78%) [15] and two other studies, 3.53% and 3.30% in the Netherlands and Italy [19,16]. The latter reported higher protein percentage values for both ovine and caprine milk in three different stages of lactation: 5.16%, 5.39% and 5.26% for ovine milk in early, middle and end stage of lactation respectively and 3.29%, 3.62% and 4.03% for caprine milk in early, middle and end stage of lactation, respectively. Higher protein values were demonstrated for ovine and caprine milk (5.21% and 3.15%, respectively) in Austria [23]. Diet may also affect protein content in ovine milk. Values of 4.88%, 5.14% and 5.35% for proteins in ovine milk were obtained on three different diets in Tunisia [19], which values relate to those obtained by other studies with values of 4.98% and 5.47% [22,24] and for ewes fed different diets (5.56% and 5.62 [25].

Higher mean values for protein were obtained in Greece [21] for ovine milk (6.3%) in both spring and summer and for caprine milk (3.71%and 3.44%) in spring and summer respectively. Conversely, in France [26] values for caprine milk (3.22-3.23%) were lower than the above mentioned studies but are similar to values obtained in this present study. A hypothetical reason for lower values of protein in milk of the Maltese Islands could be the forage to concentrate ratio in livestock diet. The cost of concentrates and importation costs may force farmers to feed less concentrates to livestock. Also compared to other countries, Maltese farms hold a lower number of heads leading farmers to feeding more roughage to limit expenses. Protein results in this study highlight the urge for local studies to be carried out on the physico-chemical characterization of local forage to establish forage quality and nutritional aspects.

Lactose content

The major carbohydrate in caprine, ovine and bovine milk is the milk sugar lactose [8,28]. It constitutes an average of 4.1%, 4.9% and 4.7% of caprine, ovine and bovine milk, respectively. The mean concentration of lactose in bovines, ovines and caprines did not vary significantly between Malta and Gozo ($p>0.07$). Interspecies differences were significant with ovine milk consisting of a higher concentration of lactose (5.56±0.37%) as compared to caprine and bovine (4.42±0.35% and 4.2±0.13%) milk lactose content ($p<0.05$). The approximate 4.2% of lactose in bovine milk obtained in this study is lower than values on 134 dairy cows: Swedish red and white, Swedish Holstein and Danish Holstein-Frisian breed [15], and two other studies in Italy and the Netherlands [16,18] (4.78%, 4.53% and 4.51%, respectively). Conversely, in another study in Italy [22], results show that different lactation stages affect lactose of ovine milk (4.70 - 4.72%). Another study in Austria reported values of 4.64% and 4.32% for ovine and caprine milk [23]. Values between 4.44% and 5.06% for ovine milk were obtained in various studies [20,21,24,25]. These were lower than the approximate mean lactose obtained in this present study. On the other hand, the mean lactose content in caprine milk obtained in this study seem to be comparable with results obtained in France (4.4% and 4.33% [26]) and Greece (4.53% and 4.26% [21]), but higher than those obtained in Italy (3.97%-4.31% [22]).

Salt content

Salts in dairy contribute to a substantial amount of nutrients such as Ca, P, K and Mg and even though they are present in small amount in milk (approximately <1%) they play an important role in the milk's technological properties as some salts influence stability and physical state of protein particularly caseinate [18,29]. No significant difference in the mean percentage of salts for bovine, ovine and caprine milk between Malta and Gozo was observed ($p>0.06$). Interspecies differences were significant with ovine milk salt concentration (0.80±0.07%) being higher as compared to bovine and caprine (0.60±0.02% and 0.60±0.05%) milk salt concentration ($p<0.05$).

Several studies [7;18,21;25;29,30-37] report the analysis of the mineral content that contribute to the salt content.

Freezing point

The freezing point of milk is an important physical property as it can be used as a parameter to determine milk adulteration hence to evaluate the milk quality [38]. However, freezing point may be affected by other factors such as heat treatment and seasonality [39]. In general, the average freezing point value in raw ovine milk decreases during the summer months [39]. High temperatures and dehydrated livestock may be potential causes for this depression.

There was no significant difference in the mean freezing point for bovine, ovine and caprine milk between the two localities ($p>0.15$). However interspecies differences were observed with ovine milk (-0.727±0.09°C) being significantly different from the freezing point bovine and caprine milk (-0.493±0.02°C and -0.527±0.05°C) respectively ($p<0.05$).

These results correlate to results (-0.519°C) obtained from milk deriving from Holstein-Friesian cows [18]. In another study the freezing point for caprine and ovine milk were -0.544°C and -0.542°C, respectively [23]. Lower values were obtained for ovine milk from two other studies (-0.578°C and -0.561°C, [20,40] respectively).

pH

The pH of milk is naturally slightly acidic. A reduction in milk pH demonstrates that the milk is souring. Bacteria play a very important role in milk pH. Certain types namely lactobacilli, convert the sugars in milk into acids hence reducing its pH. On the other hand, there are other bacteria that convert milk components into ammonia products hence increasing the pH. Therefore, milk pH can also serve as an indication of livestock health.

There was no significant difference in mean pH of ovine and caprine milk between Malta and Gozo ($p>0.39$); however a significant difference was observed in bovine milk samples between the two localities ($p<0.05$). Interspecies differences were significant, with bovine milk pH (6.42±0.14) being higher as compare to ovine and caprine (6.35±0.21 and 6.32±0.18) milk pH ($p<0.05$).

Similar patterns were also observed in similar studies with pH values of 6.7, 6.64 and 6.61 for bovines [29,15,41], ovines and caprines [29], respectively. In another study [42], pHs ranged between 5.75 and 6.72 in bovine milk, which is an indication of milk freshness, according to the authors. Other studies show minimal interspecies pH differences [16,17,23]

Conductivity

Conductivity can be a potential indicator for subclinical mastitis as the conductivity in milk increases with infection. From the values obtained in this study, it can be demonstrated that milk samples were collected from mastitis-free herds.

There is a significant difference in the mean conductivity of bovine milk between Malta and Gozo ($p<0.05$) however no difference can be observed in the mean conductivity of ovine and caprine milk between the two islands ($p>0.78$). The mean values for conductivity of bovine (4.7±0.1mS/cm), ovine (4.8±0.1mS/cm), and caprine (4.5±0.1mS/cm) milk are significantly different ($p<0.05$).

In another study [42], the conductivity ranged from 2.36 to 5.70 mS/cm in nine milk samples resulting in a mean value of 4.20mS/cm. Several studies [43-45] concluded that conductivity can be a potential indicator for subclinical mastitis as this increases with infection. Hence, results in this study demonstrate that the fresh milk samples were collected from mastitis-free herds.

Principal component analysis

The main objective of running a factor analysis (the screen plot) is to reduce the large number of variables to ease interpretation of results. Figure 1 reveals that the first four factors explain most of the variability in the original eight factors hence the first four factors are a simpler substitute for all eight. However, since the program is a 2-dimensional model, the next highest value of some variables in F3-F8 is compressed in F1 and F2 and hence only F1 and F2 are plotted in the variables plot. Pearson correlation (Table 2) and the variables plot (Figure 2) reveal that the milk fat content, milk pH, and conductivity are unrelated to all other variables. Conversely, there is a good relationship between proteins, lactose, SnF and salt content in milk and milk Fp. The positive relationship between proteins, lactose, SnF and salts (r>0.974) demonstrate that these variables are directly related with each other but are inversely related to the Fp (r < -0.941). The solid-non-fat portion of milk is primarily constituted of proteins, lactose, and minerals (salts: including Ca and P) [46]. Hence serves as an indication of the positive relationship between these four variables. The negative correlation of various parameters with Fp confirms that with respect to these parameters, the freezing point is a negative indicator for milk quality [47]. State that freezing point is proportional to the concentration of milk's water-soluble characteristics. The same authors also mention that the milk fat globules, casein micelles and whey proteins are not particularly associated with a lower Fp. However, according to [48], the Fp of milk is determined by water-soluble constituents (including Ca, K and Mg), and lactose. Figure 1 demonstrates that ovine milk in both Malta and Gozo has distinctive characteristics as compared to bovine and caprine milk. This relates to the discussed physicochemical parameters, also confirming the statistical analysis obtained through the Analysis of Variance.

Conclusion

The objectives of this study which consisted of an analysis of milk deriving from bovine, ovine, and caprine, in Malta and Gozo, were: to evaluate the physicochemical characterization of the milk of the three species andto determine any interspecies differences and differences between localities. In summary, this study revealed minor differences in milk physicochemical characterization between farms in Malta and Gozo. However, interspecies differences were observed (Figure 2). Ovine milk demonstrated distinctive characteristics in terms of fats, SnF, proteins, lactose, salts and Fp. Data of proximate analysis indicated that fats, SnF, proteins and lactose were highest for ovine milk, followed by caprine and bovine milk respectively. Results revealed that bovine and caprine milk were similar with regards to salt content and milk Fp. The pH was highest for bovine milk and the conductivity ranges for the milk of the three species may be an indication that samples were collected from mastitis-free herds.

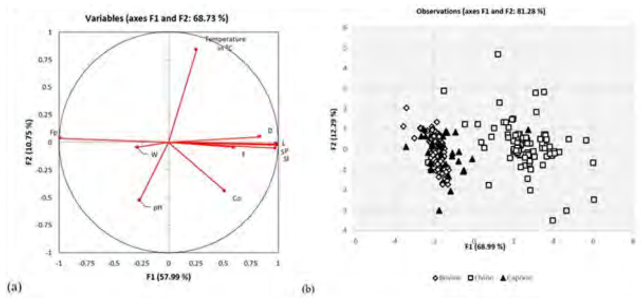

Figure 1: Principal Component Analysis: (a) the factor loading plot demonstrating the different groups of variables; (b) the factor scores of the two latent factors.

Figure 2: Visual representation of the interspecies differences for the parameters under study.

Variables	F	SnF	D	Fp	P	L	Sl	W	pH	Co
Temp	0.137	0.229	0.215	-0.230	0.238	0.227	0.197	-0.036	-0.236	-0.129
F		0.541	0.184	**-0.624**	0.497	0.554	0.536	-0.233	-0.197	0.362
SnF			**0.831**	**-0.993**	**0.996**	**0.999**	**0.978**	-0.232	-0.197	0.446
D				**-0.789**	**0.843**	**0.827**	**0.807**	-0.191	-0.186	0.326
Fp					**-0.983**	**-0.994**	**-0.973**	0.226	0.198	-0.465
P						**0.993**	**0.974**	-0.225	-0.196	0.439
L							**0.976**	-0.232	-0.201	0.451
Sl								-0.237	-0.179	0.448
W									0.130	-0.120
pH										-0.178

Table 2: Pearson correlation matrix for the studied parameters.

Temp (temperature), F (fats), P (proteins), L (lactose), Fp (freezing point); SnF (solid non-fat), D (density), Sl (salts), W (added water), pH, Co (conductivity).

The unique characteristics of ovine milk could explain the contrast in flavour between cheeselets made from ovine milk and cheeses produced from bovine milk and hence the reason for the majority of local consumers preferring the traditional cheeselets to be made from ovine milk rather than bovine milk. This is a positive attribute particularly since the 'traditional' Maltese cheeselet necessitates the sole usage of raw ovine milk. Although, the values of many parameters revealed no extreme differences between bovine and caprine milk, the differences in milk characterization of these two species cannot be underestimated particularly due to the fact that there are other parameters such as casein to protein ratio and casein micelle properties, milk fat globule size, and fatty acid composition that even though not accounted for during this study may contribute towards the diverse flavour profile in milk of the two species. Even though this particular study did not reveal any unique features for bovine milk with regards to the studied proximate parameters, it is worth noticing that bovine milk is characterized by the ability of cream to separate quickly favouring cheese production, and is rich in beneficial minerals and fatty acids, and such benefits in bovine milk cannot be undervalued. This study provides the basis of Maltese milk quality hence providing a physicochemical characteristics of normal milk vis-à-vis adulterated or mixed milk samples.

References

1. Vella JG (2015) Veterinary Regulation Directorate, Marsa, Malta. Personal communication.
2. Spiteri R, Attard E (2017) Determination of Major and Minor Elements in Maltese Sheep, Goat and Cow Milk Using Microwave Plasma-Atomic Emission Spectrophotometry. Journal of Agricultural Science 9: 43-50.
3. Archer SC, Green MJ, Huxley JN (2010) Association between milk yield and serial locomotion score assessments in UK dairy cows. J Dairy Sci 93: 4045-4053.
4. O'Driscoll K, Olmos G, Moya SL, Mee JF, Earley B, et al. (2012) A reduction in milking frequency and feed allowance improves dairy cow immune status. J Dairy Sci 95:1177-1187.
5. Morales MBL, BintsisT, Alichanidis E, Herian K, Jelen P, et al (2017) Soft Cheeses (with Rennet), in Global Cheese making Technology: Cheese Quality and Characteristics, Papademas P, Bintsis T Eds., John Wiley & Sons, Ltd: Chichester, UK.: 301-325.
6. Carloni M, Fedeli D, Roscioni T, Gabbianelli R, Falcioni G (2010) Seasonal variation of fat composition in sheep's milk from areas of central Italy. Mediterranean Journal of Nutrition and Metabolism 3: 55-60.
7. Hilali M, El-Mayda E, Rischkowsky B (2011) Characteristics and utilization of sheep and goat milk in the Middle East. Small Ruminant Research 101:92-101.
8. Park YW, Juárez M, Ramos M, Haenlein GF (2007) Physico-chemical characteristics of goat and sheep milk. Small Ruminant Research 68:88-113.
9. Zervas G, Tsiplakou E (2011) The effect of feeding systems on the characteristics of products from small ruminants. Small Ruminant Research 101:140-149.
10. Domagała J (2009) Instrumental texture, syneresis and microstructure of yoghurts prepared from goat, cow and sheep milk. International Journal of Food Properties12: 605-615.
11. Trancoso IM, Trancoso MA, Martins AP, Roseiro LB (2010) Chemical composition and mineral content of goat milk from four indigenous Portuguese breeds in relation to one foreign breed. International Journal of Dairy Technology 63: 516-522.
12. Ribeiro AC, Ribeiro SD (2010) Specialty products made from goat milk. Small Ruminant Research 89: 225-233.
13. Claeys WL, Cardoen S, Daube G, De Block J, Dewettinck K, et al. (2013) Raw or heated cow milk consumption: Review of risks and benefits. Food Control 31: 251-262.
14. Claeys WL, Verraes C, Cardoen S, De Block J, Huyghebaert A, et al. (2014) Consumption of raw or heated milk from different species: An evaluation of the nutritional and potential health benefits. Food Control 42: 188-201.
15. Wedholm A, Larsen LB, Lindmark-Månsson H, Karlsson AH, Andrén A (2006) Effect of protein composition on the cheese-making properties of milk from individual dairy cows. Journal of Dairy Science 89: 3296-305.
16. Comunian R, Paba A, Daga E (2011) Evaluation of a Microbial Indicator Test for Antibiotic Detection in Ewe, Goat and Cow Milk. In IDF International Symposium on Sheep, Goat and Other non-Cow Milk Pg no: 16-18.
17. Mallatou H, Pappa EC (2005) Comparison of the characteristics of teleme cheese made from ewe's, goat's and cow's milk or a mixture of ewe's and goat's milk. International Journal of Dairy Technology 58: 158-163.
18. Bijl E, Van Valenberg HJ, Huppertz T, Van Hooijdonk AC (2013) Protein, casein, and micellar salts in milk: Current content and historical perspectives. J Dairy Sci 96: 5455-5464.
19. Maamouri O, Atti N, Kraiem K, Mahouachi M (2011) Effects of concentrate and Acacia cyanophylla foliage supplementation on nitrogen balance and milk production of grazing ewes. Livestock Science 139: 264-270.
20. Antunac N, Mikulec N, Bendelja D, Prpić Z, Barać Z (2008) Characterisation and research of the milk quality in Krk cheese manufacturing. Mljekarstvo: časopiszaunaprjeđenjeproizvodnjeiprerademlijeka 58: 203-222.
21. Kondyli E, Svarnas C, Samelis J, Katsiari MC (2012) Chemical composition and microbiological quality of ewe and goat milk of native Greek breeds. Small Ruminant Research 103: 194-199.
22. Comunian R, Paba A, Dupré I, Daga ES, Scintu MF (2010) Evaluation of a microbiological indicator test for antibiotic detection in ewe and goat milk. J Dairy Sci 93: 5644-5650.
23. Mayer HK, Fiechter G (2012) Physical and chemical characteristics of sheep and goat milk in Austria. International Dairy Journal 24: 57-63.
24. Marques MR, Bernardino S, Ribeiro JM, Belo AT, Belo CC (2012) Sheep Milk: Yield, Composition and Potential Cheese Yield. Bulletin of the International Dairy Federation 1201:44.
25. Martini M, Salari F, Altomonte I, Rignanese D, Chessa S, et al, (2010) The Garfagnina goat: a zootechnical overview of a local dairy population. Journal of Dairy Science 93: 4659-4667.
26. Lefrileux Y, Raynaud S, Morge S, Barral J, Gauzere Y, et al. (2009) The effects of two diets on milk production and milk composition of high producing dairy goats milked once-a-dav and technological impact for lactic cheese-making on the farm. 16 èmes Rencontres autour des Recherches sur les Ruminants, Paris : 139-42.
27. Pereira PC (2014) Milk nutritional composition and its role in human health. Nutrition 30: 619-627.
28. Jandal JM (1996) Comparative aspects of goat and sheep milk. Small Ruminant Research 22: 177-185.
29. Bornaz S, Sahli AL, Attalah A, Attia H (2009) Physicochemical characteristics and renneting properties of camels' milk: a comparison with goats', ewes' and cows' milks. International Journal of Dairy Technology 62: 505-513.
30. Ataro A, McCrindle RI, Botha BM, McCrindle CM, Ndibewu PP (2008) Quantification of trace elements in raw cow's milk by inductively coupled plasma mass spectrometry (ICP-MS). Food Chemistry 111: 243-248.

31. Dobrzanski Z, Kolacz R, Górecka H, Chojnacka K, Bartkowiak A (2005) The content of microelements and trace elements in raw milk from cows in the Silesian region. Polish Journal of Environmental Studies 14: 685.

32. El Sayed EM, Hamed AM, Badran SM, Mostafa AA (2011) A survey of selected essential and heavy metals in milk from different regions of Egypt using ICP-AES. Food AdditContam Part B Surveill 4: 294-298.

33. Herwig N, Stephan K, Panne U, Pritzkow W, Vogl J (2011) Multi-element screening in milk and feed by SF-ICP-MS. Food Chemistry 124:1223-1230.

34. Khan ZI, Ashraf M, Al-Qurainy F, Ahmad K, Gondal S, et al. (2011) Studies on the transfer of copper from soil to pastures at different sampling periods: a case study of a semiarid region (Sargodha) in Pakistan. Biol Trace Elem Res 141:126-130.

35. Mayer HK, Fiechter G (2012) Physical and chemical characteristics of sheep and goat milk in Austria. International Dairy Journal 24: 57-63.

36. Şanal H, Güler Z, Park YW (2011) Profiles of non-essential trace elements in ewe and goat milk and their yoghurt, torba yoghurt and whey. Food AdditContam Part B Surveill 4: 275-281.

37. Sola-Larrañaga C, Navarro-Blasco I (2009) Chemometric analysis of minerals and trace elements in raw cow milk from the community of Navarra, Spain. Food Chemistry 112: 189-196.

38. Pintić-Pukec N, Barać Z, Dakić A, Stručić D, Blažek D (2011) Determination of the freezing point in cow milk samples preserved with azidiol. Mljekarstvo 61:336.

39. Janštová B, Navrátilová P, Králová M, Vorlová L (2013) The freezing point of raw and heat treated sheep milk and its variation during lactation. ActaVeterinaria Brno 82: 187-190.

40. Sajko-Matutinović L, Pavic V, Mioč B, Antunac N, Prpić Z, et al. (2012) Sezonskepromjenenekihfizikalno-kemijskihodlikamlijekaovacadalmatinskepramenke / Seasonal changes of some physical-chemical characteristics of milk from Dalmatian Pramenka ewes. Mljekarstvo/Dairy 62: 2.

41. Chen B, Lewis MJ, Grandison AS (2014) Effect of seasonal variation on the composition and properties of raw milk destined for processing in the UK. Food Chemistry 158: 216-223.

42. Perween R, Bhutto AB, Ara DA, Shaukat SS, Haq QU (2013) Elucidation of physico-chemical characteristics and mycoflora of bovine milk available in selected area of Karachi, Pakistan. Journal of Applied Sciences and Environmental Management 17: 259-265.

43. Diaz JR, Romero G, Muelas R, Sendra E, Pantoja JC, et al. (2011) Analysis of the influence of variation factors on electrical conductivity of milk in Murciano-Granadina goats. J Dairy Sci 94: 3885-3894.

44. Fernando RS, Rindsig RB, Spahr SL (1982) Electrical conductivity of milk for detection of mastitis. J Dairy Sci 65:659-664.

45. Romero G, Pantoja JC, Sendra E, Peris C, Díaz JR (2012) Analysis of the electrical conductivity in milking fractions as a mean for detecting and characterizing mastitis in goats. Small Ruminant Research 107:157-163.

46. Bauman DE, Griinari JM (2001) Regulation and nutritional manipulation of milk fat: low-fat milk syndrome. Livestock Production Science 70: 15-29.

47. Erb RE, Manus LJ (1963) Estimating solids-not-fat in herd milk using the plastic bead method of Golding. Journal of Dairy Science 46: 1373-1379.

48. Jenness R, Patton S (1959) Principles of Dairy Chemistry. John Wiley; New York.