Pakistan J. Zool., pp 1-8, 2022. **DOI**: https://dx.doi.org/10.17582/journal.pjz/20220121140148

Physicochemical and Mineral Content of Milk from Talesh Buffalos, Sheep, Goats, and Cows, Saanen Goats and Talesh-Mediterranean Buffalos: A Comparative Analysis

Luigi Liotta[1], Vincenzo Lopreiato[1], Fariborz Asroosh[2] and Alireza Seidavi[2]*

[1]Dipartimento di Scienze Veterinaire, University of Messina, Messina, Italy
[2]Department of Animal Science, Rasht Branch, Islamic Azad University, Rasht, Iran

Article Information
Received 21 January 2022
Revised 25 February 2022
Accepted 15 March 2022
Available online 15 June 2022 (early access)

Authors' Contribution
LL, AS, VL and FA performed the experiments. LL and AS drafted the manuscript. LL, AS and FA analysed the data. LL, AS and VL designed the experiments and revised the manuscript. LL, AS and VL conceived the idea.

Key words
Physicochemical composition, Macro and micro trace element, Milk, Ruminant, Breed

ABSTRACT

The aim of the present study was to compare quality, macro, and micro constituents of milk between Talesh buffalo, Talesh sheep, Talesh cow, Talesh-Mediterranean buffalo, Talesh goat and Saanen goat. Milk samples were collected during 2021. The main characteristics and constituents of milk including colour, odour, taste, freezing point, dry matter free of fat, acidity (lactic acid), density (in 15 °C), pH, fat and protein were determined according to the standard methods. Macro and micro elements of milk were analyzed using inductively coupled plasma mass spectrometry. Data were subjected to the two-way ANOVA analysis to determine the significant differences between species/breeds. The acidity, density and fat in Talesh sheep's milk was higher than milk from other species/breeds ($P<0.01$). Also, the amount of protein in Talesh sheep's milk was significantly higher ($P<0.05$) than all animals tested with the exception of Talesh buffalo milk. The pH of Saanen goat's milk was higher than the pH of milk from all other species/breeds ($P<0.01$), whereas the pH of milk from Talesh-Mediterranean buffalos was lowest ($P<0.01$). Talesh sheep's milk had the lowest freezing temperature ($P<0.01$). The results of the present study also demonstrated significant differences among species for most macro and micro elements including Al, Ba, Ca, Co, Cs, Fe, In, La, Mg, Mn, Mo, Na, P, Pd, Pt, Re, Rn, S, Sc, Sr, Se, Ta, B, Li, and Zn ($P<0.01$). Significant differences were observed for As, Ce, He, Ir, Nb, Sb and Th in sheep's milk ($P<0.05$), and K and Rb ($P<0.05$) in Talesh goat's milk compared with other species/breeds. In conclusion, buffalo milk is richer in most nutrients compared with cow's and goat's milk and should perhaps be considered a stronger candidate to meet human nutritional needs in regions of the world where they can be properly managed.

INTRODUCTION

Milk is the most nutritionally complete food that can be utilized by humans. For this reason, one of the main livestock activities in the world is raising dairy cattle. Milk comprises a complex compound that contains fats, proteins, lactose (and other sugars), minerals, vitamins, enzymes and water, as well as less-defined but nonetheless important active constituents (Piacenza *et al*., 2021). Dairy products are the best source of calcium for the human body (Polzonetti *et al*., 2020). Consumption of milk and its various products, especially fermented products, leads to increased life expectancy, increased physical and mental efficiency, reduced infectious diseases, reduced bone diseases and optimal growth of children and adolescents (Tripathi *et al*., 2019).

Due to the growing awareness of consumers about the relationship between diet and human health, food quality especially livestock products has become an important issue in food selection. Therefore, the consumption of foods that have beneficial effects on human health (useful foods) is increasing due to their high nutritional value. On the other hand, these foods should have a clear effect on health, or reduce serious diseases in humans. Milk is an example of one of these foods (Schröder and Vetter, 2013). Therefore, milk can be a very important food for human beings and contains almost all required nutrients (Ziarati *et al*., 2018). Milk and its products have been among the most important nutrients for human needs for thousands of years, which in addition to having great nutritional value, also play an important role in preventing many diseases. Numerous studies have shown the positive effect of milk and its

* Corresponding author: alirezaseidavi@iaurasht.ac.ir
0030-9923/2022/0001-0001 $ 9.00/0

products on human health and longevity (Ekmekcioglu, 2020). Milk and its products are a rich source of many nutrients such as protein, calcium, phosphorus, vitamin B2 and vitamin B12, which are recommended for daily human consumption. Milk provides the calcium needed to have strong bones, the protein needed for brain growth and body tissue growth, the vitamin A needed for normal vision, and the vitamin D needed to absorb calcium (Wimalawansa *et al*., 2018).

Daily consumption of milk in the household can, nonetheless, be very important to overall human health. Milk consumed by households globally, and in Iran specifically is generally provided by cows, followed by buffaloes and goats. Buffalo milk has a high nutritional value after sheep milk due to its high content of solids (fat, protein, carbohydrates, calcium, phosphorus and vitamin A). Thus, multiple aspects of nutritional value in buffalo milk increases the quality and health value of buffalo dairy products (Garau *et al*., 2021).

In Iran, about 89% of the total milk production of the country is obtained from cows. Sheep and goat milk provided 7 and 3% respectively with the remainder including buffalo and camel milk (Statistics Center of Iran, 2012). Dairy processing supplies dairy producers with more cash than raw milk sales and offers better opportunities to reach local and urban markets. Milk processing also provides the opportunity to cope with seasonal fluctuations in milk supply. Converting raw milk to processed milk and other products can benefit all communities by creating off-farm jobs in milk collection, transportation, processing and marketing (FAO, 2019).

Approximately 150 million households worldwide produce milk. In the last three decades, world milk production has grown by more than 50%. Among lactating animals, cows have the largest share of milk production in the world with 83%, the rest of the milk production is related to buffalo, sheep, goats, and other animals (Adesogan and Dahl, 2020).

The main constituents of milk are water, fat, lactose, whey proteins and minerals (ash). The composition of milk is very variable and. In addition, genetic, physiological, and nutritional factors, as well as environmental conditions, play a large role in creating these differences. Fat is the most variable component of milk, which varies even throughout the day and depends on the individual characteristics of the animals (Pietrzak-Fiećko and Kamelska-Sadowska, 2020).

Research findings indicate that mineral and trace element content in milk varies depending on species and breeds, lactation number, nutritional status, mineral supplements, geographical conditions, and environmental chemical contaminants (Park *et al*., 2017).

Some species are targeted for milk production, including cattle, goats, sheep, buffalo, and camels. Milk nutrients of interest are water/ solids, protein, fat, sugars, ash (minerals). Hence, our aim was to investigate breed and species differences in milk quality and mineral constituents from animals sampled from the same general location.

MATERIALS AND METHODS

Milk samples collection

Milk samples were collected in 2021from six species/ breeds in Talesh, Ardeh, Dinachal and Khaleh Sara summer villages of Guilan province, Iran. All herds were maintained in semi-open grazing systems with animals fed on natural pastures supplemented with concentrate/hay diets. Milk samples were stored at -18°C until prepared for analysis.

Milk samples analysis

Colour, odour, taste, freezing point, dry matter free of fat, acidity (lactic acid), density (at 15°C), fat and protein were determined according to standard methods (AOAC, 1990). The pH was measured with a digital pH meter (microprocessor pH meter, Cyberscan, Italy 510 pH) calibrated with 4 and 8.6 buffers.

Milk samples were prepared and analyzed using inductively coupled plasma mass spectrometry (ICP-MS, 7500 Series, Agilent, Santa Clara, CA, USA) at the Aria Sharif Chemical Laboratory (Karaj, Iran). Briefly, 6 g samples of homogenous thawed milk samples were immersed in a 2:1 (v/v) mixture of 65% nitric acid (Merck, Darmstadt, Germany) at 70°C to totally dissolve the spines. The obtained solution was then mixed with distilled water in a sampling vial to a volume of 50 mL. ICP-MS was used to measure milk Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Hg, Ho, In, Ir, K, La, Li, Lu, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Pd, Pr, Pt, Re, Rh, Ru, Rb, S, Sb, Sc, Se, Sm, Sn, Sr, Ta, Tb, Te, Th, Ti, Tl, Tm, U, V, W, Y, Yb, Zn and Zr. A multi-element standard (1094870100SKU, Merck) was used for instrument calibration every five samples. The operational conditions for the ICP-MS were optimized following the manufacturer's instructions (RF power 1,500 W, nebulizer gas flow rate 0.6 L min^{-}1, plasma gas flow rate 12 L min^{-}1, auxiliary gas flow rate 1 L min^{-}1, integration time 6 s).

Statistical analysis

All data were examined for normality and homogeneity of variances before running the statistical analyses and transformed if necessary. The statistical analysis was performed using the two-way ANOVA (Zar, 1996) based on a completely randomized design. The statistical design was as $X_{ij} = \mu + T_j + e_{ij}$ where X_{ij} shows number of each control in experiment, μ was total average of society that was considered zero through samples, T_j shows effects of each group of experimental treatment and e_{ij} shows the effect of the error. The total value of any observed treatment effects, and the average test error was the result of the whole population. All statistical analyses were performed with the SPSS (1996) software package and differences of $P<0.05$ were considered significant.

RESULTS

The color, odour and taste of all milk samples was normal. The results of this study are presented in Tables I-IV. The percentage of defatted solids, acidity, density and fat of Talesh sheep's milk was higher than the milk of other species ($P<0.01$). The protein concentration in Talesh sheep's milk was higher than the milk from other species, except from Talesh buffalo milk ($P<0.05$). The pH of Saanen goat's milk was higher than milk from other species, whereas the pH of sheep, goat and buffalo milk samples were higher than Mediterranean buffalo milk ($P<0.01$). Talesh sheep's milk had the lowest freezing temperature ($P<0.01$).

Table I. Physico-chemical characteristics of first lactation milks from different ruminant species/breeds sampled in Iran (wet basis).

Ruminants	pH	Freezing point (°C)	Acidity (Lactic acid) (%)	Density (in 15°C)
Talesh buffalo	6.78p^{b}	-0.59^{b}	0.18^{bc}	1.03^{bc}
Talesh-Mediterranean buffalo	6.13^{d}	-0.58^{ab}	0.27^{a}	1.03^{bc}
Talesh sheep	6.69^{b}	-0.68^{c}	0.28^{a}	1.04^{a}
Saanen goat	6.91^{a}	-0.57^{a}	0.15^{c}	1.03^{bc}
Talesh goat	6.71^{b}	-0.59^{b}	0.19b^{c}	1.03^{b}
talesh cow	6.51^{c}	-0.58^{ab}	0.23^{ab}	1.03^{c}
SEM	0.23	0.003	0.013	0.000
P-value	<0.0001	<0.0001	<0.0001	<0.0001

Means within a column with different letters are different ($P<0.05$).

This study showed that there were significant differences in macro and micro elements of milk from the different species. Sheep milk had the highest content of the elements Al, Ba, Ca, Co, Fe, In, La, Mg, Mn, Mo, Na, P, Pd, Pt, S, Sc, Sr and Ta ($P<0.01$). However, Saanen goat milk had the highest level of B, Li and Re and Talesh buffalo milk had the highest level of Cs, Se and Zn ($P<0.01$).

Table II. Milk nutrient composition in different species/ breeds of ruminants sampled in Iran (wet basis).

Ruminants	Dry matter free of fat (%)	Fat (%)	Protein (%)
Talesh buffalo	9.19^{b}	5.8^{b}	4.6^{a}
Talesh-Mediterranean buffalo	8.91^{c}	5.27^{c}	3.20^{b}
Talesh sheep	12.80^{a}	9.77^{a}	4.60^{a}
Saanen goat	8.68^{d}	3.57^{f}	4.17^{ab}
Talesh goat	9.00^{bc}	4.63^{d}	3.80^{ab}
Talesh cow	8.92^{c}	4.07^{e}	3.33^{ab}
SEM	0.047	0.033	0.286
P-value	<0.0001	<0.0001	0.014

Means within a column with different letters are different ($P<0.05$).

Finally, a significant difference was observed in macro and micro elements of sheep milk As, Ce, He, Ir, Nb, Sb and Th ($P<0.05$). Although Talesh goat milk had the highest level in terms of element K, but with the amount of K milk of Talesh sheep, cows and buffaloes and Saanen goat was in the same level and there was a significant difference with the amount of K milk of Mediterranean buffalo ($P<0.05$). Also, Talesh goat milk had the highest amount of Rb trace element, but with Rb value of Talesh cow and buffalo milk, Mediterranean buffalo and Saanen goat were on a statistical level and there was a statistically significant difference with Rb value of sheep milk.

DISCUSSION

Buffalo milk has many advantages in terms of nutritional quality and chemical composition and is characterized by the content of fat, total solids, proteins, caseins, lactose and ash compared to cow's milk (Bekere and Husen, 2020). In fact, various factors such as species, breed, nutritional system, lactation stage and season affect the chemical composition and nutritional qualities (Ahmad *et al*., 2013). However, cow's milk has long been considered a very nutritious and valuable food for humans and is consumed in millions of dairy products (Mahmoud and Sumayra, 2010).

Salman *et al*. (2014) examined the difference between cow's milk and buffalo milk in a study. The researchers said that the protein content of buffalo milk was significantly higher than cow's milk. The protein content of Talesh buffalo milk and Talesh cow's milk observed in the present study was consistent with the findings of Salman *et al*. (2014). Mahmoud and Sumayra (2010) reported more protein in buffalo milk than in cow's milk. However, the results reported by Enb *et al*. (2009) did not support

Table III. Milk macro-mineral (ppm) composition in different species/breeds of ruminants sampled in Iran (wet basis).

Macro-minerals (ppm)	Talesh buffalo	Talesh-Mediterranean buffalo	Talesh sheep	Saanen goat	Talesh goat	talesh cow	SEM	P-value
Ca	1041.56^{b}	744.24^{bc}	1541.25^{a}	518.18^{c}	1003.48^{b}	684.87^{bc}	96.35	<0.0001
P	503.65^{bc}	408.68^{cd}	879.26^{a}	360.11^{d}	602.43^{b}	443.42^{cd}	24.44	<0.0001
Na	289.50^{b}	284.96^{bc}	475.23^{a}	226.62^{d}	233.30^{cd}	188.87^{d}	11.69	<0.0001
K	776.20^{ab}	549.43^{b}	746.10^{ab}	852.55^{ab}	1090.10^{a}	762.99^{ab}	87.90	0.023
Mg	93.84^{ab}	55.68^{b}	139.91^{a}	68.10^{b}	84.45^{b}	56.73^{b}	10.24	0.001
S	257.14^{b}	164.59^{b}	472.37^{a}	135.69^{b}	227.56^{b}	154.67^{b}	27.62	<0.0001

Means within a row with different letters are different ($P<0.05$).

Table IV. Milk trace mineral composition in different species/breeds of ruminants sampled in Iran (wet basis).

Trace mineral (ppb)	Talesh buffalo	Talesh-Mediterranean buffalo	Talesh sheep	Saanen goat	Talesh goat	Talesh cow	SEM	P-value
Cu	97.88^{a}	172.10^{a}	30.49^{a}	71.11^{a}	47.63^{a}	56.32^{a}	68.60	0.736
Fe	921.67^{b}	890.00^{b}	1350.00^{a}	930.00^{b}	820.00^{b}	890.00^{b}	73.34	0.003
Mn	66.47^{b}	67.03^{b}	89.67^{a}	54.38^{bc}	62.96^{b}	40.89^{c}	4.54	<0.0001
Pb	6.42^{a}	17.50^{a}	8.65^{a}	11.25^{a}	12.52^{a}	7.56^{a}	4.19	0.492
Zn	4029.01^{a}	2300.89^{ab}	3149.64^{ab}	813.44^{b}	2706.16^{ab}	2422.64^{ab}	422.36	0.004
Se	247.88^{a}	44.03^{c}	54.01^{bc}	18.65^{c}	27.33^{c}	241.86^{ab}	40.51	0.003
Ag	0.61^{a}	1.39^{a}	10.00^{a}	5.74^{a}	6.79^{a}	1.59^{a}	3.22	0.307
Al	204.86^{b}	300.37^{ab}	440.73^{a}	302.63^{ab}	260.78^{b}	253.33^{b}	34.31	0.007
As	3.93^{ab}	1.06^{b}	11.49^{a}	2.89^{ab}	2.78^{ab}	0.92^{b}	1.92	0.02
B	410.33^{c}	390.00^{c}	590.00^{b}	680.00^{a}	510.00^{b}	410.00^{c}	17.71	<0.0001
Ba	260.67^{ab}	100.00^{b}	430.00^{a}	90.00^{b}	240.00^{ab}	110.00^{b}	51.91	0.004
Be	0.36^{a}	0.10^{a}	0.10^{a}	0.07^{a}	0.10^{a}	0.29^{a}	0.107	0.306
Bi	0.58^{a}	1.83^{a}	2.71^{a}	1.11^{a}	0.82^{a}	0.53^{a}	0.66	0.211
Cd	0.221	0.199^{a}	0.29^{a}	0.18^{a}	0.11^{a}	0.18^{a}	0.06	0.37
Ce	0.10^{b}	0.23^{b}	0.82^{a}	0.46^{ab}	0.17^{b}	0.24^{b}	0.12	0.012
Co	0.88^{b}	0.83^{b}	2.43^{a}	0.68^{b}	1.53^{ab}	0.83^{b}	0.28	0.005
Cr	10.44^{a}	3.97^{a}	6.37^{a}	5.51^{a}	5.53^{a}	4.22^{a}	3.17	0.737
Cs	1.46a	0.61^{ab}	0.49^{ab}	0.31^{c}	0.74^{b}	0.38^{ab}	0.09	<0.0001
Dy	0.10^{a}	0.08^{a}	0.14^{a}	0.099^{a}	0.07^{a}	0.09^{a}	0.02	0.163
Er	0.10^{a}	0.10^{a}	0.08^{a}	0.09^{a}	0.10^{a}	0.09^{a}	0.01	0.761
Eu	0.10^{a}	0.10^{a}	0.11^{a}	0.09^{a}	0.10^{a}	0.09^{a}	0.01	0.954
Ga	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0	1
Gd	0.09^{a}	0.09^{a}	0.13^{a}	0.11^{a}	0.09^{a}	0.08^{a}	0.02	0.608
Ge	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0	1
Hf	0.19^{a}	0.17^{a}	1.37^{a}	0.30^{a}	0.27^{a}	0.16^{a}	0.27	0.049
Hg	9.18^{a}	6.05^{a}	15.96^{a}	9.26^{a}	13.46^{a}	5.74^{a}	3.14	0.215
Ho	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0	1

Table continueS on next page..................

Trace mineral (ppb)	Talesh buffalo	Talesh-Mediterranean buffalo	Talesh sheep	Saanen goat	Talesh goat	Talesh cow	SEM	P-value
In	0.10^{b}	0.08^{b}	0.43^{a}	0.17^{b}	0.13^{b}	0.13^{b}	0.05	0.002
Ir	0.51^{b}	0.73^{ab}	1.65^{a}	0.999^{ab}	0.55^{ab}	0.63^{ab}	0.24	0.041
La	0.10^{c}	0.14^{c}	0.73^{a}	0.53^{ab}	0.19^{bc}	0.15^{bc}	0.08	<0.0001
Li	6.73^{ab}	1.67^{b}	0.10^{b}	20.82^{a}	0.10^{b}	1.134^{b}	3.26	0.005
Lu	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0	1
Mo	27.75^{bc}	34.59^{b}	58.16^{a}	11.96^{cd}	6.87^{d}	28.26^{bc}	3.74	<0.0001
Nb	2.48^{ab}	1.52^{b}	16.08^{a}	3.05^{ab}	2.52^{ab}	1.76^{b}	3	0.033
Nd	0.16^{a}	0.23^{a}	0.55^{a}	0.30^{a}	0.29^{a}	0.23^{a}	1	0.188
Ni	9.78^{a}	1.45^{a}	24.27^{a}	7.86^{a}	36.15^{a}	1.14^{a}	9.64	0.137
Pd	0.09^{b}	0.10^{b}	0.39^{a}	0.14^{b}	0.11^{b}	0.07^{b}	0.04	0.002
Pr	0.14^{a}	0.14^{a}	0.23^{a}	0.19^{a}	0.11^{a}	0.17^{a}	0.02	0.115
Pt	0.10^{b}	0.10^{b}	0.54^{a}	0.24^{b}	0.14^{b}	0.100^{b}	0.06	0.001
Re	0.14^{c}	0.10^{c}	0.55^{b}	1.05^{a}	0.10^{c}	0.10^{c}	0.03	<0.0001
Rh	0.09^{b}	0.08^{b}	0.33^{a}	0.20^{ab}	0.14^{b}	0.11^{b}	0.03	0.001
Ru	0.10^{a}	0.12^{a}	0.09^{a}	0.09^{a}	0.09^{a}	0.10^{a}	0.01	0.422
Rb	737.77^{ab}	596.02^{ab}	274.37^{b}	519.48^{ab}	961.69^{a}	422.08^{ab}	121.25	0.023
Sb	0.74^{ab}	0.61^{b}	1.19^{a}	0.79^{ab}	0.73^{ab}	0.63^{b}	0.09	0.012
Sc	4.98^{b}	4.34^{bc}	6.63^{a}	3.34^{c}	5.00^{b}	4.35^{bc}	0.23	<0.0001
Sm	0.09^{a}	0.10^{a}	0.18^{a}	0.15^{a}	0.09^{a}	0.13^{a}	0.03	0.23
Sn	27.38^{a}	4.79^{a}	18.04^{a}	6.98^{a}	8.03^{a}	5.84^{a}	8.91	0.45
Sr	290.40^{c}	570.00^{bc}	990.00^{a}	640.00^{b}	480.00^{bc}	300.00^{c}	64.14	<0.0001
Ta	6.88^{b}	4.38^{b}	24.560^{a}	6.16^{b}	5.64^{b}	4.17^{b}	3.40	0.008
Tb	0.10^{a}	0.10^{a}	0.09^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.00	0.458
Te	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0	1
Th	1.76^{b}	1.75^{b}	5.21^{a}	2.28^{b}	2.13^{b}	1.75^{b}	0.61	0.011
Ti	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0	1
Tl	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0	1
Tm	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0	1
U	1.42^{a}	1.25^{a}	1.24^{a}	1.33^{a}	1.18^{a}	1.43^{a}	0.08	0.188
V	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0	1
W	5.26^{a}	2.07^{a}	8.23^{a}	2.92^{a}	2.39^{a}	2.58^{a}	1.89	0.231
Y	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0	1
Yb	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0.10^{a}	0	1
Zr	3.53^{a}	2.22^{a}	3.29^{a}	2.30^{a}	2.17^{a}	2.34^{a}	0.90	0.467

Means within a row with different letters are different (P<0.05).

the present findings and found less protein in buffalo and cow's milk. The higher protein content of buffalo milk than cow's milk may be due to the concentration of both casein and whey proteins, which has been reported to be higher in buffalo milk than in cow's milk (Sindhu, 1998). In general, species diversity in milk protein content may be due to changes in the genetic composition of the animal (Walstra *et al*., 2006). In fact, it can be said that animals that grow faster (according to their size) need milk with more protein, because it provides the necessary materials for the growth of muscle tissue (Park *et al*., 2017).

Milk is almost an ideal food with high nutritional value. It contains proteins for body growth, minerals that make up bone and lactose and fat for energy. In addition to providing essential fatty acids, it contains nutrients in a digestible and absorbable form. Recently, the use of colostrum and adult milk derived from various mammals in human nutrition has become increasingly popular. This is mainly due to hypocholesterolemic function, better bioavailability, therapeutic properties (used in gastrointestinal disorders) and no allergies after consuming milk. Milk fat is also one of the few food sources of butyric acid and a strong inhibitor of cancer cell proliferation (Salman *et al*., 2014). The mineral composition of cow's milk is 0.73 mg/l (Flynn, 1992), of which manganese is 2.89 (Belewu and Aiyegbusi, 2002), molybdenum is 0.05 (Park *et al*., 2017), iron is 0.81 (Anderson. 1992). Copper was 0.03 µmol/L (Licata *et al*., 2004), calcium was 0.58% (Hurley, 1997), and magnesium was 87 µg/ml (Fransson and Linnerdal, 1993) as 87 µg/ml (Fransson and Linnerdal, 1993).

The average lactose content in buffalo milk was relatively higher than cow's milk. Similar findings have been reported by Park *et al*. (2017), who found a higher percentage of lactose in buffalo milk than in cow's milk. The present observations are consistent with the findings of Mahmoud and Sumayra (2010), who found a similar trend for lactose content in buffalo and cow's milk. However, the results of Bzoska *et al*. (2011) do not support the findings of the present study, which did not show a comparable difference between the lactose concentrations of buffalo and bovine milk. In addition, the results of the present study are not in agreement with the findings of Myburgh *et al*. (2012).

The use of milk and dairy products in any local area mainly follows economic factors and climatic conditions, food habits, peoples' food tastes and the level of technology. The biological value of the proteins in milk is equal to the percentage of nitrogen absorbed, which is maintained in the body to ensure growth and survival. Milk protein contains 80% casein, 20% soluble protein. The milk composition varies not only from one species to another but also in different breeds, while environmental factors (age, season, nutrition, health, and lactation (stage and parity) in turn cause changes in milk composition (Getaneh *et al*., 2016).

Buffalo milk has ~5% less water than cow's milk, thus its dry matter, protein, fat and carbohydrates are correspondingly higher than cow's milk (Foroutan *et al*., 2019). The main factor in determining the energy of milk is primarily its fat content. Buffalo milk contains 97 kcal and cow's milk has 60 kcal per 100 ml. Contrary to the misconceptions and opinions of a group of people, no credible scientific source has so far banned or restricted the consumption of buffalo milk.

Sheep and buffalo milk were higher in quality compared with goat, and cow's milk. We suggest that a larger emphasis on sheep and buffalo milk may result in human health benefits. In general, the amount of solids in buffalo milk is about 5% more than cow's milk, which is consistent with the results of this study, so that after Talesh sheep, the amounts of lean solids, fat and protein in Talesh buffalo milk had the highest average.

The total amount of minerals in buffalo milk is more than cow's milk. On average, buffalo milk contains higher percentages of calcium, phosphorus, potassium, sodium, magnesium, manganese, iron and copper than cow's milk (Singh *et al*., 2019) which was consistent with the results of the present study. However, it has been previously reported a lower amount of zinc in buffalo milk compared with cow's milk, resulting in contrast with the results of the present study, so that the amount of zinc had the highest level among the milk of other species.

The worldwide production of goat's milk is the third highest after cow and buffalo. A female goat of high-breed breeds gives an average of 3.8 liters of milk per day. Goat's milk is similar to cow's milk but differs from buffalo (and sheep) milk in taste, composition, type and amount of nutrients. Goat's milk fat particles are smaller in size as well as quantity compared with buffalo milk, so goat's milk is easier to digest and is better for children, the elderly and those with digestive disorders (Panta *et al*., 2021). Perhaps one of the best benefits of goat's milk is that people who do not tolerate cow's milk can consume goat's milk with fewer problems (Verruck *et al*., 2019). Some anti-inflammatory compounds (such as polysaccharides) in goat's milk make it easier to digest. In general, buffalo milk solids are about 4% higher than in goat's milk, and buffalo milk is richer in protein, carbohydrates and especially fat than goat's milk. The amount of energy in 100 ml of buffalo milk is 97 kcal, but this amount is 69 kcal in goat milk. Although the total amount of minerals in buffalo milk is less than in goat's milk, the concentrations of Ca, Na, Mn and Cu in Iranian cow's and goat's milk is quite similar. Furthermore, the reported higher concentrations of P, Mg and Fe, and lower K and Zn in buffalo milk compared with goat's milk (Chen *et al*., 2020) is confirmed from Iranian animals raised in the same environment in this study. So, buffalo milk is richer in most nutrients compared with cow's milk and goat's milk and should perhaps be considered a stronger candidate for improving health status or meeting human nutritional needs in regions of the world where they can be properly managed.

CONCLUSION

Buffalo milk is richer than cow's and goat's milk in terms of total solids, fat, protein, carbohydrates, calculated energy, Ca, P, Na, Mg and Fe. Goat's milk is also richer in potassium than bovid or sheep's milk, even among the herds sampled from the same environments in Iran.

ACKNOWLEDGEMENTS

Financial support by the Rasht Branch, Islamic Azad University, grant number [17.16.1.462] is gratefully acknowledged. The research study proposed was conducted under the grant of the RSF No. 21-16-00025, SSI NIIMMP.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Adesogan, A.T., and Dahl, G.E., 2020. Milk symposium introduction: Dairy production in developing countries. *J. Dairy Sci*., **103**: 9677-9680. https://doi.org/10.3168/jds.2020-18313

Ahmad, S., Anjum, F.M., Huma, N., Sameen, A. and Zahoor, T., 2013. Composition and physico-chemical characteristics of buffalo milk with particular emphasis on lipids, proteins, minerals, enzymes and vitamins. *J. Anim. Pl. Sci.,* **23**(Suppl 1): 62-74.

Anderson, R.R., 1992. Comparison of trace elements in milk of four species. *J. Dairy Sci*., **75**: 3050–3055. https://doi.org/10.3168/jds.S0022-0302(92)78068-0

Andrieu, S., 2008. Is there a role for organic trace element supplements in transition cow health? *Vet. J*., **176**: 77-83. Available at: https://www.intechopen.com/online-first/76625, https://doi.org/10.1016/j.tvjl.2007.12.022

AOAC. 1990. *Official Methods of Analysis,* 15th edn. Association of Official Analytical Chemists, Washington, DC.

Bekere, H., and Husen, M., 2020. Review on the composition of milk of different farm animal. *Am. J. Pure appl. Biosci.,* Available at SSRN: https://ssrn.com/abstract=3713853, https://doi.org/10.2139/ssrn.3713853

Belewu, M.A. and Aiyegbusi, O.F., 2002. Comparison of the mineral content and apparent biological value of milk from human, cow and goat. *J. Food Technol. Afr*., **7**: 9-11. https://doi.org/10.4314/jfta.v7i1.19310

Brzoska, F., Wiewiora, W., Michalec, J. and Brzoska, B., 1996. Effect of magnesium oxide and dolomite limestone on cows' yield, milk composition and electrolyte content of milk and blood serum. Roczniki Naukowe Zootechniki, 23(3): 71-84.

Chen, L., Li, X., Li, Z., and Deng, L., 2020. Analysis of 17 elements in cow, goat, buffalo, yak, and camel milk by inductively coupled plasma mass spectrometry (ICP-MS). *RSC Adv*., **10**: 6736-6742. https://doi.org/10.1039/D0RA00390E

Ekmekcioglu, C., 2020. Nutrition and longevity from mechanisms to uncertainties. *Crit. Rev. Fd. Sci. Nutr*., **60**: 3063-3082. https://doi.org/10.1080/10408398.2019.1676698

Enb, A., Abou Donia, M.A., Abd-Rabou, N.S., Abou-Arab, A.A.K. and El-Senaity, M.H., 2009. Chemical composition of raw milk and heavy metals behavior during processing of milk products. *Global Vet.,* **3**: 268-275.

Erdogan, S., Celik, S. and Erdogan, Z., 2004. Seasonal and locational effects on serum, milk, liver and kidney chromium, manganese, copper, zinc, and iron concentrations of dairy cows. *Biol. Trace Elem. Res*., **98**: 51-61. https://doi.org/10.1385/BTER:98:1:51

FAO. 2019. *FAO statistics*. Available from: https://www.fao.org/faostat/en/#home

Flynn, A., 1992. Minerals and trace elements in milk. *Adv. Fd. Nutr. Res.,* **36**: 209-252.

Foroutan, A., Guo, A.C., Vazquez-Fresno, R., Lipfert, M., Zhang, L., Zheng, J., Badran, H., Budinski, Z., Mandal, R., Ametaj, B.N. and Wishart, D.S., 2019. Chemical composition of commercial cow's milk. *J. Agric. Fd. Chem*., **67:** 4897-4914. https://doi.org/10.1021/acs.jafc.9b00204

Fransson, G.B. and Lönnerdal, B., 1983. Distribution of trace elements and minerals in human and cow's milk. *Pediatr. Res.,* **17**: 912-915. https://doi.org/10.1203/00006450-198311000-00015

Garau, V., Manis, C., Scano, P., and Caboni, P., 2021. Compositional characteristics of mediterranean buffalo milk and whey. *Dairy*, **2**: 469-488. https://doi.org/10.3390/dairy2030038

Getaneh, G., Mebrat, A., Wubie, A., and Kendie, H., 2016. Review on goat milk composition and its nutritive value. *J. Nutr. Hlth. Sci*., **3**: 401-410. https://doi.org/10.15744/2393-9060.3.401

Hurley, W.L., 1997. *Lactation biology. Minerals and vitamins*. University of Urbana, Illinois, USA.

Licata, P., Trombetta, D., Cristani, M., Giofre, F., Martino, D., Calo, M. and Naccari, F., 2004. Levels of “toxic” and “essential” metals in samples of bovine milk from various dairy farms in Calabria, Italy. *Environ. Int*., **30**: 1-6. https://doi.org/10.1016/S0160-4120(03)00139-9

Mahmood, A. and Sumayra, U., 2010. A comparative study on the physicochemical parameters of milk samples collected from buffalo, cow, goat and sheep of Gujrat, Pakistan. *Pakistan J. Nutr.*, **9**: 1192-1197.

Myburgh, J., Osthoff, G., Hugo, A., De Wit, M., Nel, K., and Fourie, D., 2012. Comparison of the milk composition of free-ranging indigenous African cattle breeds. *S. Afr. J. Anim. Sci*., **42**: 1-14. https://doi.org/10.4314/sajas.v42i1.1

Panta, R., Paswan, V.K., Gupta, P.K., and Kohar, D.N., 2021. *Goat's milk (GM), a booster to human immune system against diseases.* https://doi.org/10.5772/intechopen.97623

Park, Y. W., Heanlein, G.F.W. and Wendorff, W.L. 2017. *Handbook of milk of non-bovine mammals*. John Wiley & Sons Ltd. 729 pages.

Piacenza, E., Chillura, M.D.F., Cinquanta, L., Conte, P., and Lo, M.P., 2021. Differentiation among dairy products by combination of fast field cycling NMR relaxometry data and chemometrics. *Magn. Reson. Chem.*, **60**: 369-385. https://doi.org/10.1002/mrc.5226

Pietrzak-Fiećko, R., and Kamelska-Sadowska, A.M., 2020. The comparison of nutritional value of human milk with other mammals' milk. *Nutrients*, **12**: 1404. https://doi.org/10.3390/nu12051404

Polzonetti, V., Pucciarelli, S., Vincenzetti, S., and Polidori, P., 2020. Dietary intake of vitamin d from dairy products reduces the risk of osteoporosis. *Nutrients*, **12**: 1743. https://doi.org/10.3390/nu12061743

Salman, M., Khaskheli, M., Israr-Ul-Haq, A.R.T., Khuhro, A.P., Rauf, M., Hamid, H., and Aziz, A., 2014. Comparative studies on nutritive quality of buffalo and cow milk. *Int. J. Res. appl. natl. Soc. Sci*., **2**: 69-78.

Schröder, M., and Vetter, W., 2013. Detection of 430 fatty acid methyl esters from a transesterified butter sample. *J. Am. Oil Chem. Soc*., **90**: 771-790. https://doi.org/10.1007/s11746-013-2218-z

Sindhu, J.S., 1998. *Chemical aspects of cow and buffalo milk in relation to quality of traditional dairy products*. Lecture compendium on “Advances in traditional dairy products”, Fourth short course, Centre of Advanced Studies, NDRI, Karnal, India, pp.12-16.

Singh, M., Sharma, R., Ranvir, S., Gandhi, K., and Mann, B., 2019. Profiling and distribution of minerals content in cow, buffalo and goat milk. *Indian J. Dairy Sci.*, **72**: 480-488. https://doi.org/10.33785/IJDS.2019.v72i05.004

SPSS, 1996. *SPSS base 7.5 for windows user's guide*. SPSS, Chicago, IL, USA.Statistics Center of Iran, 2012. *Iran statistics.* Available from: https://www.amar.org.ir/

Tomlinson, D.J., Mulling, C.H. and Fakler, T.M., 2004. Invited review formation of keratins in the bovine claw: Roles of hormones, minerals, and vitamins in functional claw integrity. *J. Dairy Sci*., **87**: 797-809. https://doi.org/10.3168/jds.S0022-0302(04)73223-3

Tripathi, A.D., Mishra, R., Maurya, K.K., Singh, R.B., and Wilson, D.W., 2019. Estimates for world population and global food availability for global health. In: *The role of functional food security in global health.* Academic Press. pp. 3-24. https://doi.org/10.1016/B978-0-12-813148-0.00001-3

Verruck, S., Dantas, A., and Prudencio, E.S., 2019. Functionality of the components from goat's milk, recent advances for functional dairy products development and its implications on human health. *J. Funct. Fd.*, **52**: 243-257. https://doi.org/10.1016/j.jff.2018.11.017

Walstra, P., Wouters, J.T.M. and Geurts, T.J., 2006. *Dairy science and technology*. Taylor and Francis group editors.

Wimalawansa, S.J., Razzaque, M.S., and Al-Daghri, N.M., 2018. Calcium and vitamin D in human health: Hype or real? *J. Steroid Biochem. Mol. Biol.*, **180**: 4-14. https://doi.org/10.1016/j.jsbmb.2017.12.009

Zar, J.H., 1996. *Biostatistical analysis.* Prentice Hall, United Kingdom.

Ziarati, P., Shirkhan, F., Mostafidi, M., and Zahedi, M.T., 2018. An overview of the heavy metal contamination in milk and dairy products. *Acta Sci. Pharm. Sci.*, **2**: 1-14. https://doi.org/10.5604/01.3001.0012.7111