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Research Article

Physicochemical and Nutritional Characteristics of Milk Collected from Camels, Cows and Goats in Korahay Zone, Somali Region, Ethiopia: A Comparative Study

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ABSTRACT

Humans consume domesticated animals' milk frequently, either directly as a fluid or after processing it to make various dairy products like butter and cheese. Camel, cow and goat milks are essential nutrients supply where all humans are dependent on consuming this milk intake. This study assessed the nutritive and physicochemical properties of cow, goat, and camel milk, and then compared the main ingredients composition, physicochemical characteristics to clarify the overall quality differences among cows', goats' and camels' milk. The analyzed parameters were pH, temperature, freezing point, titrable acidity, solid non-fat, ash, lactose, proteins fats and nutrients (Mg, Na, K, Ca, Cd, Cr, Cu, Mn, Pb and Zn). The results showed that the goat milk had the highest pH (7.05 ± 0.00), temperature (26.25 ± 0.35), and conductivity (4.065 ± 0.055), total solid (13.665 ± 0.045, ash (0.97 ± 0.003%), proteins (4.14 ± 0.01%) and fats (6.415 ± 0.005%). The Freezing points for each species were almost in agreement with each other. The highest solid non-fat content was for camel milk (10.08 ± 0.06). The cow milk had the highest lactose content (4.78 ± 0.00%). The nutritive result revealed that camel milk had high levels of K (7.274 ± 0.266 mg/L), and the Mn concentration were Below Detection Limit (BDL). The goat milk had the highest level of Na (8.625 ± 0.044) and lowest level of Cd (0.029 ± 0.006 mg/L). In this study the concentration of all studied nutrients in milk samples were not in agreement with World Health Organization (WHO) limit. This study also compared the analyzed nutrients with other countries result reported in literatures.

Keywords: Camel; Cow; Lysozyme; Lactoferrin; Vitamins; Minerals

INTRODUCTION

According to literatures reported recently, milk is the most important food for newborns in all mammalian species, supplying energy, proteins, fat, carbohydrates, and micronutrients, such as vitamins and minerals [1,2]. Therefore, it is considered a complete food, very important in the human diet both for children and adults [3,4]. Milk consumption is estimated at around 85 kg/year/per capita, even if there are large differences among different areas for instance in sub-Saharan Africa, is about 30 kg/year/per capita, in the Middle East and North Africa, about 87 kg/year/per capita, and in Latin America, it is about 113 kg/year/per capita [4,5]. According to a number of surveys, milk is a fantastic source of calcium, magnesium, zinc and it provides very small amount of iron and copper [6,7]. In addition, milk products are the main constituent of human daily diet, especially for vulnerable groups such as infant, school age children, as well as old aged people [8,9]. The same types of elements, but in varied amounts, are present in every milk for example 87.5% of cow's milk in the United States is made up of water, 4.9% lactose (a carbohydrate), 3.4% fat, 3.3% protein, and 0.7% ash [10]. Milk Production in Ethiopia possesses the largest livestock population in Africa [11-13]. Recent estimates indicated that the country have about 50.9 million heads of cattle, 24.06 million goats, 25.5 million sheep and 2.3 million camels [11]. Milk production system can be categorized based on agro-ecology, socio-economic structures of the population and type of breed and species used for milk production can be classified into two major systems, namely rural dairy system (pastoralists, agro-

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pastoralists, and mixed crop–livestock producers) and urban and peri-urban dairy systems [14]. Milk is consumed globally, especially by infants, and is significant economically in many nations [15], A current global problem is the contamination of milk with hazardous substances [16]. This is a result of growing industrial, commercial, and agricultural operations that may lead to higher concentrations of hazardous heavy metals in the atmosphere, water, plants, and soil [17]. Long term exposure to heavy metals through food may have chronic consequences on a person's heart, neurological system, liver, and kidney [18]. The most major source of milk in the desert is said to be camel milk. It has nutrients that are good for human health [19,20]. Camel milk is unlike other ruminant milk in that it has low cholesterol, low sugar, high minerals (sodium, potassium, iron, copper, zinc, and magnesium), high vitamin C, and protective proteins like lactoferrin, lactoperoxidase, Immunoglobulin's, and lysozyme. It is the closest milk to human milk of any kind [21]. Cow's milk has long been considered a highly nutritious and valuable human food and is consumed by millions daily in variety of products [22]. Goat has been referred as the poor man's cow'' due to its great contribution to the health and nutrition of the landless and rural poor [23]. Goat milk differs from cow or human milk in having better digestibility, alkalinity and buffering capacity [24]. The population in the Korahe zone of somali regional state of Ethiopia consumes milk products from cows, camels, and goats. But the presence of nutrients has not been used to evaluate the quality of milk. To imply that no investigation was conducted for determination of these nutrients and physicochemical properties with regard to their importance and potential harm to human health. Therefore, the aim of the present study was to determine the concentrations of the nutrients, such as: Mg (Magnesium), Na (Sodium), K (Potassium), Ca (Calcium), Cd (Cadmium), Cr (Chromium), Cu (Copper), Mn (Manganese), Pb (Lead) and Zn (Zinc) and physicochemical parameters in fresh cow's, camel's, and goat's milk collected from Kebridehar and Shilavo sites of Korahay Zone, Somali region, Ethiopia. The obtained mean elemental concentrations were compared with the corresponding values of different countries reported in the literature.

MATERIALS AND METHODS

Description of the study area

Somali regional state of Ethiopia is the second largest region of the country following Oromia region by having a land cover of 350,000 Kilometer Square. It has a border with Somalia, Djabouti and Kenya countries. Similarly, Somali region bordered with Afar and Oromia regions in West. Somali region has 93 districts and 11 zonal administrates in which Korahay is one of them. Korahay zone had in 2007 a total population of 312,713, of whom 177,919 were men and 134,794 were women [25]. The topography of the study area is predominantly lowland plain with an average altitude of 493 m above sea level with a few foothills of higher altitude by having latitude and longitude of 6044'25''N,440 16'38''E, respectively. The climate of Korahe zone is characterized as tropical semiarid in which temperature ranges from 23 to 36. The area has bimodal rainfall pattern with two main rainy seasons in which the first is 'Gu' that occurs from mid-April to the end of June. The second rainy season known as 'Deyr' occurs from early October to late December. In the Somali region, camel is a leading animal because of the multipurpose role it has on the provision of milk, meat, social and cultural importance besides unpaid transport service [25]. The national survey (CSA) indicated that Korahay zone has 115,498 total number of 106 camels and 5 number of camel per square kilometer which makes Korahay zone the second richest zone in camel production following Warder Zone of Somali regional state (Figure 1) [26].

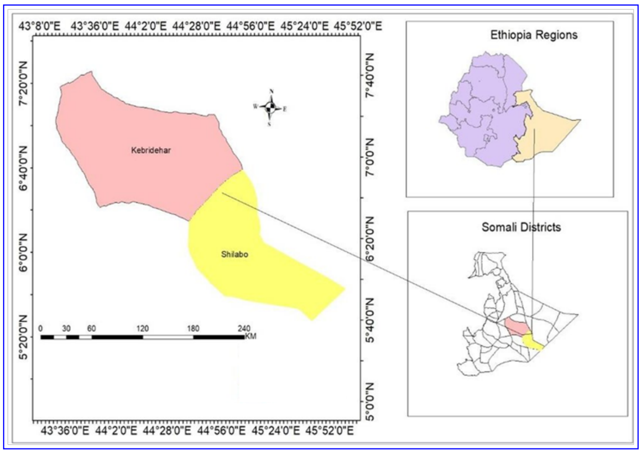

Figure 1: Geographical map of the study areas [11].

Apparatus

The apparatus that were used in this study are Butyrometer, Digital Electronic balance, Conductivity meter, and pH meter. All glassware was washed before use with distilled water, soaked in slightly nitric acid, rinsed in distilled water and air dried. The glassware was kept in clean place to avoid contamination.

Reagents and chemicals

All the chemicals used were of analytical reagent grade and purchased from Sigma-Aldrich (St. Louis, USA). Sodium hydroxide, Nitric acid (68%), hydrogen peroxide (32%) (Sigma-Aldrich St. Louis, USA) and deionized water was used for cleaning sample holders and preparation of all solutions. Nitric acid (68%) and hydrogen peroxide (32 %) was used for digesting milk samples throughout the work. The standard solutions (99.99 %) of Ca, K, Mg, Na, Cu, Cr, Mn, Pb, Cd, and Zn corresponding to 1000 mg/L of each metal was prepared by sequential dilution of stock standards from Sigma Ald-rich (St.Louis, USA). Working standards were prepared from intermediate standards of each metal.

Sample collection and sampling methods

The polyethylene sampling bottles was soaked in HNO3 for 24 hours and rinsed with distilled water before collection of raw milk in order to avoid possible contamination. The udder of each species (cow, camel, and goat) was washed with distilled water before milking. Sixty (60) fresh milk samples were collected directly from the udder of lactating camels; cows and goats (20 milk samples from each species) from different farmers and randomly selected from two districts of Korahay zone namely Kabridahar and Shilavo. The districts were considered purposively for its high camel, cow and goat resources and accessibility. A milk sample was collected during morning milking time from each species and kept in an ice box. The samples were collected for each animal separately and then mixed in separate clean bottles and homogenized and microwave digestion was carried out.

Analysis of physicochemical properties of milk

The physicochemical properties like temperature, pH, freezing point, added water, total solids, protein, fat and lactose content were tested using lactoscan (LAC-SPA-19578). In detail the milk sample was homogenized by turn up down the sample bottle. The lactoscan was cleaned with lactoscan cleaning acid and alkaline and rinsed with distilled water three times. The pH of lactoscan was also calibrated using standard buffers of pH 4.00 and 7.00. Then a certain amount of milk was poured into a measuring cylinder and samples were taken in the sample tube and put in the sample holder one at a time with the analyzer in the recess position. Then when the starting button activated, the analyzer sucks the milk, makes the measurements, and returns the milk in the sample tube and the digital indicator shows the specified results of freezing point, density, pH, and chemical compositions of fat, protein, lactose, and solid not-fat [27].

Determination of ash content

The ash content of milk samples was determined according to Tesfay et al., [28]. The dried milk samples used for the determination of total solids content were ignited in a muffle furnace at a temperature of 550°C until the samples were free from carbon (residue appears grayish to white) for four hours, then the samples were transferred to the desiccator to cool down. The dish containing the sample was then reweighed after the dish was completely cooled. The ash percent of the sample was calculated as follows:

$$\%Ash = \frac{Weightofresidue}{Weightofsample} \times 100$$

Determination titrable acidity

The Titrable Acidity (TA) of the milk sample was tested following the standard methods of AOAC, 2005 [29]. Milk samples of 5 mL were added into a 50 mL white crucible and 3-4 drops of 0.5% phenolphthalein indicators were added and stay for two minutes. After two minutes it was titrated with standard 0.1 N sodium hydroxide until a faint pink color persists for 10 seconds. The TA of the sample was calculated as follows:

$$\%TA = \frac{MLOF\,0.1NNaOH \times 0.09}{mLofsampleused} \times 100$$

Determination solids not-fat

Solids Not Fat (SNF) content was determined by difference as reported by Shibiru et al., [30] using the following formula:

$$SNF = \%\,\text{Totalsolid} - \%\,\text{Fat}$$

Determination of conductivity

It is well known that every liquid has temperature dependency while measurement of electrical conductivity [31]. The conductivity of milk was measured byan electrical conductivity (HACHHQ40 d multifunctional portable meter). Pouring 100 mL of each milk sample into a beaker separately at different temperature. For each sample, the measurements were repeated three times [32].

Sample digestion procedure

The optimized microwave digestion procedure was used depending upon the clarity of digests, minimal digestion time, and minimum reagent volume, absence of undigested milk samples, simplicity and low heating temperature. In this study 5 mL of (cow's, camel and goat) milk from each sample was treated with 10 mL 68% nitric acid and 3 mL 32% hydrogen peroxide and transferred to dried digestion vessels. The digestion vessels were placed in a microwave digestion system at 180 °C (30 min) and kept until brown fumes disappeared, indicating completion of oxidation of organic matter. After heating, the closed sample bottles were cooled to room temperature to avoid foaming and splashing and the digestion vessels was opened carefully in a fume hood. The cold clear solution was filtered in to 100 mL volumetric flask using Whatman filter paper (0.45 µm pore diameter membrane) to remove any suspended residues. 14 mL of 1% nitric acid was added to the solution and diluted up to the mark with distilled water and used for analysis. Digestion of blanks was also performed in parallel with the milk samples keeping all the digestion parameters the same.

Preparation of standard solution

Standard solution was prepared from 1000 ppm stock solution of metals (Ca, K, Mg, Na, Cd, Cr, Cu, Zn, Pb and Pd (Palladium)). Intermediate standard solution was prepared from 1000 mg/L stock solution. Intermediate standard solution of each metal was used to prepare all working standards.

Calibration curve and determination of metal concentrations

The linearity studied of the studied metals was in the range between 0.002 ppm and 15 ppm. Calibration curve for all the metals showed good linearity with coefficients of determination (R2) ranged between 0.9968 ppm and 0.9991 ppm. This showed that there is a good correlation between concentration and absorbance indicating good calibration of the instruments. Series of working standards and correlation coefficient of the calibration curves for determination of metals in milk using Atomic Absorption Spectroscopy (AAS) were obtained as shown in Table 1.

Evaluation of analytical method validation

Analytical results must be evaluated to decide on the best values to report and establish the probable limits of errors of these values [33]. In this study the precision of the results was evaluated by the standard deviation of the triplicate samples (n=3), analyzed under the same conditions. Most of the results in both the spiked and real sample showed very less standard deviation indicating high precision. The accuracy and validity of procedure used for digestion was evaluated by analyzing the digests of spiked sample. The recoveries of the detected metals in the spiked milk samples were described in Table 2. These values showed that the method is very accurate and valid for the determination of metals under study. The percentage recoveries were calculated according to Amha et al., (Table 2) [34].

Table 1: The correlation coefficient of calibration curves for determination of metals in milk by AAS.

Metals	Symbol	Concentration of standards (mg/L)	Equation of regression	Correlation coefficient
Magnesium	Mg	2,4,6,8,10,12	Y=(0.18x)-(0.0245)	0.9968
Calcium	Ca	0.5,1.5,2.5,3.5,4.5	Y=(0.0869x)+(0.0302)	0.9991
Potassium	K	2,4,6,8,10,12	Y=(0.1558x)+(0.0351)	0.9985
Sodium	Na	5,7,9,11,13, 15	Y=(0.0915x)-(0.3242)	0.9985
Manganese	Mn	1,2,4,6,8	Y=(0.0012x)-(0.0002)	0.9995
Copper	Cu	0.2,0.6,1,1.4,1.6,1.8	Y=(0.3084x)-(0.0226)	0.9989
Cadmium	Cd	0.02,0.5,1,1.5,2	Y=(0.0085x)+(0.0007)	0.9981
Chromium	Cr	0.1,0.4,0.6,0.8,1	Y=(0.0077x)+(0.0003)	0.9988
Zinc	Zn	0.5,1,1.5,2,2.5,3	Y=(0.0103x)-(0.0016)	0.9968
Lead	Pb	0.002,0.004,0.006,0.008,0.01	Y=(1.02x)-(0.001)	0.9988

Table 2: Analytical results obtained for the validation of the optimized procedure.

Metal	Amount spiked (mg/L)	Concentration in sample (mg/L), n=3	Concentration in spiked sample (mg/L)	% Recovery
Mg	1.5	4.594 ± 0.036	6.09 ± 0.0305	100
Ca	1.5	1.350 ± 0.029	2.71 ± 0.057	91
K	1.5	7.001 ± 0.019	8.52 ± 0.157	101.2
Na	1.5	6.647 ± 0.109	8.27 ± 0.054	108.6
Mn	1.5	1.417 ± 0.417	3.08 ± 0.42	111
Cu	1.5	0.673 ± 0.016	1.80 ± 0.006	75.4
Cd	1.5	0.212 ± 0.059	1.62 ± 0.058	94.1
Zn	1.5	1.417 ± 0.097	2.73 ± 0.048	87.5

$$\%Recovery = \frac{CA - CB}{SA} \times 100$$

CA=Concentration in spiked sample

CB=Concentration in sample

SA=Spiked amount

Statistical analysis

The data were analyzed by using Statistical Package for Social Sciences (SPSS). Statistical significant differences between means were calculated by one-way Analysis of Variance (ANOVA) test at $p<0.05$.

RESULTS AND DISCUSSION

Some physicochemical properties

The physicochemical characteristics such as pH, temperature, freezing point, total solid, conductivity, titrable acidity, ash, protein, fat, solid not fat and lactose are important parameters in studying the physicochemical compositions of milk (Table 3).

The pH values

pH is a numeric scale used to specify whether the solution is acidic or alkaline. Solutions with pH less than 7.0 are acidic and solution with pH greater than 7.0 are basic [35,36]. Milk is slightly acidic close to neutral. 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 [37]. The pH values of the fresh milk samples of the studied areas were in range of 6.85-7.05 that are slightly acidic in nature except goat milk. In particular, the goat milk of both Kebridehar and Shilavo were almost equal (7.05) it is greater than both cow and camel. The pH values of cow and camel milks in both areas were close to each other (6.95) of Kebridehar and (6.85) Shilavo respectively. In this study, the average pH values of fresh cow, camel and goat milk samples was greater than the average pH values of fresh milk samples of the same animals' species reported by Ahmida et al., in Libya [38]. Also the average pH values of cow, camels and goats' milks in our study was greater than the average pH values of milk samples of the same animal species measured in Ethiopia Somali region and the result were for cow (6.30), for camel (6.13) and for goat (6.38) respectively [39]. Lingathurai et al., reported the average pH of cow milk from different location of Madurai, Tamil Nadu were (6.44 ± 0.25) [40]. According to Sudharani et al., the average pH of cow and goat milk of north coastal Andhra Pradesh were (6.63 ± 0.02 and 6.64 ± 0.05) respectively which is below our studied result [41].

Table 3: Physico-chemical properties of raw milk of cows, camels, and goats of two studied site.

Parameters	Cow		Camel		Goat	
	Kebridehar	Shilavo	Kebridehar	Shilavo	Kebridehar	Shilavo
pH	6.95 ± 0.07	6.85 ± 0.07	6.9 ± 0.005	6.96 ± 0.01	7.05 ± 0.01	7.05 ± 0.00
Temperature	20.25 ± 1.25	22.35 ± 1.05	23.6 ± 0.50	22 ± 0.60	26.25 ± 0.35	23.35 ± 0.85
Freezing point	0.55 ± 0.00	0.55 ± 0.001	-0.55 ± 0.00	-0.5 ± 0.003	-0.497 ± 0.002	-0.501 ± 0.0
% Total solid	10.83 ± 0.08	10.4 ± 0.10	12.55 ± 0.545	13.3 ± 0.60	13.665 ± 0.045	13.85 ± 0.05
Conductivity	3.16 ± 0.02	3.30 ± 0.01	3.505 ± 0.015	3.285 ± 0.05	4.065 ± 0.055	3.95 ± 0.04
Titrable acidity	0.34 ± 0.02	0.295 ± 0.025	0.225 ± 0.009	0.252 ± 0.01	0.30 ± 0.02	0.27 ± 0.018
Added water	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.76 ± 0.18	4.415 ± 0.385	3.55 ± 0.29
Ash%	0.95 ± 0.0055	0.93 ± 0.003	0.67 ± 0.256	0.92 ± 0.002	0.97 ± 0.003	0.97 ± 0.003
% protein	3.18 ± 0.00	3.165 ± 0.00	2.975 ± 0.005	2.98 ± 0.00	4.105 ± 0.015	4.14 ± 0.01
%Fat	3.46 ± 0.00	3.44 ± 0.02	3.45 ± 0.01	3.22 ± 0.00	6.415 ± 0.005	6.395 ± 0.01
Solid not fat	7.37 ± 0.08	6.96 ± 0.08	9.10 ± 0.535	10.0 ± 0.06	7.245 ± 0.04	7.455 ± 0.05
Lactose	4.78 ± 0.00	4.74 ± 0.00	4.765 ± 0.005	4.475 ± 0.00	3.885 ± 0.005	3.93 ± 0.01

The World Health Organization (WHO) guideline recommended values for pH in milk is (6.6-6.8) [35]. However, the pH of milk changes over time [36]. According to East African Standards, for instance the recommended raw cow milk pH is also 6.6 to 6.8 [42]. Therefore, according to the standards, the average pH of our study were not in agreement with the normal pH range.

Temperature

The average temperature of milk collected from goat's milk (26.25) of Kebridehar was higher than those of the cows (20.25) and camels (23.6) milk. The average temperature of milk collected from of goat's milk (23.35 ± 0.85) of Shilavo was higher than those of the cows (22.35 ± 1.05) and camels (22.0 ± 0.60). The average temperature of milk collected from cow's (22.35 ± 1.05) of Shilavo was almost equal with that of the camel's milk (22.0 ± 0.60).

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 used as one of the quality criteria for insuring high-quality milk [43]. The freezing point of milk is determined largely to either prove or determine the amount of water supplied to the milk [44]. However, freezing point may be affected by other factors such as heat treatment and seasonality [37]. A great deal of research demonstrates definitively that milk's freezing point differs within relatively small ranges. Some of the differences that do exist have been linked to seasonal impacts, diet, water intake, timing of the day (e.g., morning versus evening milk), breed, and sampling techniques. Table 3 shows the freezing point of milk samples collected from Kebridehar and Shilavo districts. The freezing points of cow milk from the Kebridehar and Shilavo areas (-0.550) and (-0.550), camel milk from the Kebridehar and Shilavo areas (-0.550) and (-0.520), and goat milk from the Kebridehar and Shilavo areas (-0.497) and (-0.501) respectively showed that there was no significant difference ($p>0.05$) in the freezing points of the milk from each study site. There might be adulteration of solutes in Kebridehar camel milk and Shilavo camel and goat milk whereas water adulteration in milk might be high in Kebridehar area camel milk. The results of this finding of milk were in agreement with the ranges of average pH and reported milk freezing point [45-47].

Total solid content

In the present study, the data indicated that there is presence of significant difference ($p<0.05$) in the total solids content between milk samples showed in Table 3. The results illustrated that the concentration of total solids was in a range of 10.4 to 10.83% in cow milk, 12.55 to 13.3% in camel milk and 13.665 to 13.85% in goat milk. From this result, the amount of total solid in milk of cow in both study sites was similar whereas the total solid content in milk of camel from Shilavo was greater than that of Kebridehar and there was significant difference ($p<0.05$). The total solid content of milk of goat was slightly greater than that of cow and camel. There is also significant difference ($p<0.05$) between cow and camel milk but there is non-significant difference in camel milk and goat milk. The values of total solid of milk samples collected from cow and camel of Kebridehar was lower. But camel milk of Shilavo was almost similar as compared with result reported by Legesse et al., in Ethiopia [39] and higher than the work reported by Kanwal et al., [48]. The %Total Solid in goat milk was lower than the reported result by Legesse et al., [39] and higher than the reported result by Imran et al., [49].

Conductivity

The conductivity range of all the milk samples were from (3.16 ±

0.02 mS) to (4.065 ± 0.055 mS). In animal milk samples, minimum conductivity was recorded for the cow milk of Kebridehar (3.16 ± 0.02 mS) followed by the camel milk of Shilavo (3.285 ± 0.015 mS) and the highest was measured for the goat milk of Kebridehar (4.065 ± 0.055 mS). The conductivity of milks of cow and camel in this investigation was lower than the reported result by Imran et al., [49]. The conductivity is mainly due to the presence of various electrolytes. The difference in conductivity may be due to the different levels of the electrolytes present in the milk samples. The result of this study showed that, the conductivity of goat milk>camel milk>cow milk. The WHO guide line Codex Satan 243-2003 conductivity of milk recommended was 3.84-4.06 mS. Therefore, the current study result is in agreement with the recommended value.

Titrable acidity

The measurement of acidity is a measure of milk bacterial contents and the freshness of milk samples [38,50]. The values of titrable acidity of milk samples collected from cow, camel and goat and are given in Table 3. It was observed from results that the values of titrable acidity were in the range of 0.295-0.34% in cow milk, 0.225-0.252% in camel milk and 0.27-0.30 in goat milk. Difference between the values of titrable acidity of cow, camel and goat milk was non-significant ($p>0.05$). However, the average acidity values of fresh milk samples of the cow, camel and goat is higher than the average acidity values of fresh milk samples of the same animals' species measured in Legesse, et al., work [39]. The average acidity values of fresh milk samples of the cow, and goat of our work is higher than the average acidity values of fresh milk samples of cow, and goat species determined in Kanwal et al., study [48]. The acidity of cow milk in our study were greater than the acidity in cow milk as stated by Enb et al., [6].

Ash content

The water contained in milk or any other food is removed by evaporation and the residue is incinerated to a white or nearly white ash containing minerals [51]. The white ash is mainly composed of oxides and chlorides of mineral elements, which include lime, magnesia, soda ash, potash, phosphorus oxides, sulfur trioxide, ferric oxide, etc. [35]. The results of this study revealed that the ash content was in the range of 0.93-0.95% in cow milk, 0.67-0.92% in camel milk and 0.97% in goat milk. The ash content of the milk in both study areas was almost similar except the camel milk of Kebridehar which is 0.67 ± 0.256. There was non-significance ($p>0.05$) difference milk of cow, camel and goat of Kebridehar and Shilavo. The ash content in milk of, camel and goat of both studied areas except camel milk of Kebridehar were greater than same species in Ethiopia reported by Legesse et al., [39] and in Libya reported by Ahmida et al., [38].

Protein content

The main component of milk, which has a major impact on its nutritional value and technological suitability, is protein. Milk proteins are a heterogeneous group of compounds that differ in composition and properties [52]. It contains two main groups (caseins and whey proteins) and relatively higher amount immune proteins (Peptidogl-ycan recognition protein, Lactoferrin lysozyme and Lacto-peroxidase) and insulin [53-55]. Protein content in milk samples collected from cow, camel and goat is given in Table 3. According to these results, protein content was in range of 3.165 ± 0.005 to 3.18 ± 0.00 % in cow milk, 2.975 ± 0.005 to 2.98 ± 0.00 % in camel milk and 4.105 ± 0.015 to 4.14 ± 0.01 % in goat milk. The amount of protein in goat milk of both study areas was similar but it had significance difference ($p<0.05$) when compared to cow and camel milk. The amount of protein in milk of our study was in agreement with Legesse, et al., reported result [39]. Sabahelkhier et al., reported the protein content in cow (3.40) goat (3.30) and camel (2.95) which is almost similar with our studied camel milk [56]. The protein contents of fresh cow and goat milk of our study were lower than the protein contents of cow milk (4.25%) and goat milk (4.93%) as stated by Musallam et al., [57].

Fat content

Fat is the major substance defining milk's energetic value and makes a major contribution to the nutritional properties of milk. Milk fat is synthesized in the milk cells of the udder. Lipids form inclusions, which gradually increase in size, and finally migrate to the upper part of cell from which they are shed as globules into the collecting lumen [58]. Fat content in milk samples collected from cow, camel and goat of the two studied area is given in Table 3. Results illustrated that the average fat content of 3.44-3.46% in cow milk, 3.22-3.45% in camel milk and 6.395-6.415% in goat milk. From this result, the amount of fat contents of cow and camel milk are close to each other's. While, the fat contents of goat milk were higher than the fat contents of cow and camel. The values of fats contents of our study except for camel were almost similar with works of Ahmida et al., in Libya 3 % in cow milk, 4 % in camel, and 6% in Goat [38]. The amount of fats in cow's fresh milk of our study is greater than fat content in cow milk (2.15%), and (4.45%) lower goat milk but lower than camel milk (3.93%), as stated by El-Hatmi et al., [59].

Solids not-fat

The results of fresh milk samples analysis showed that the solid nonfat contents have wide concentration range from (6.96%) to (10.08%). In which, the highest solid nonfat contents were in camel milk of Shilavo area (10.08%) then camel milk of Shilavo (9.10%), goat milk of Shilavo (7.455%), cow milk of Kebridehar (7.37%), goat milk of Kebridehar and cow milk of Shilavo (6.96%) in decreasing order.

The lactose content

The main carbohydrate of milk is lactose [50]. The results of our study showed that the lactose contents of milk of cow of the two study areas is almost close to each other and the camel milk of Kebridehar were higher than Shilavo. While, the lactose contents of milk of goat were lower than that of cow and camel. The lactose contents of cow and camel milk of our samples were approximately comparable with the values of lactose contents of the same animal's species for cow (4.6%) and camel (4.53%) as reported by Musallam et al., [57]. In this work the lactose content of goat milk (4.39%) is lower than the lactose content of goat milk (6 ± 1.1) reported by Ahmida et al., in Libya [38].

Added water

The obtained results showed that there is no added water in milk of cow of both study areas and camel Kebridehar but there was added water in camel of Shilavo area (0.76 ± 0.18) and (4.415 ± 0.385 and 3.55 ± 0.29) in goat milk of both Kebridehar and Shilavo respectively. The addition of water to exploit not solely reduces the nutritionally worth of milk however conjointly contaminated water may cause a health risk [60,61]. The remains of the rinse water within the milk instrumentation before milking and therefore the addition of the wash water to the tank once the milking might be stabilized the presence of added water in milk (Figure 2) [62].

Metal concentration in milk of cow, camel, and goat

Essential micronutrients like minerals and trace elements are beneficial for physiological functions and important for the body's regular functioning. In this study, microwave digestion techniques were utilized to apply AAS in order to identify trace elements in vegan diets. The quickest, shortest, and most recently established disintegration method, the microwave digesting method, was chosen The average heavy metal concentrations in the fresh cow, camel, and goat from Kebridehar and Shilavo area of Korahay zone are presented in Table 4 and Figure 3.

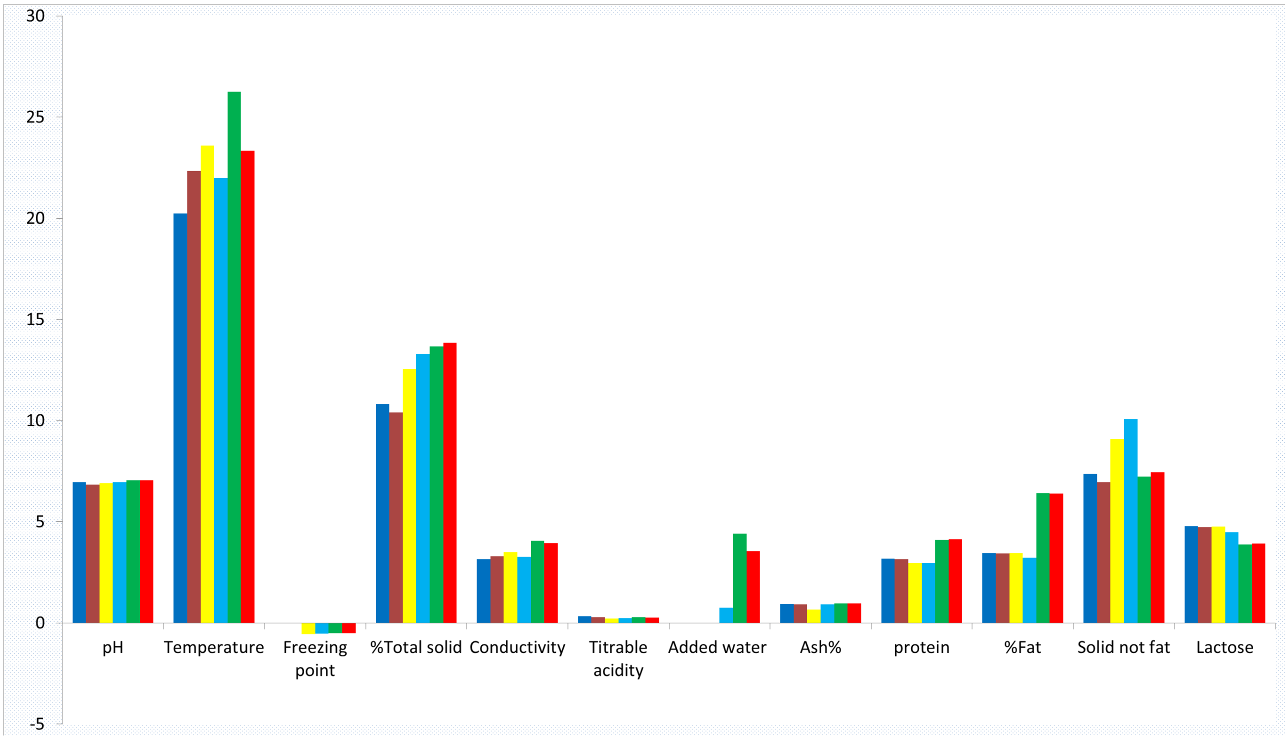

Figure 2: Histogram of the physiochemical properties of cows, camels, and goats fresh milk of both study area. **Note:** (■) Cow (Kebridehar), (■) Cow (Shilavo), (■) Camel (Kebridehar), (■) Camel (Shilavo), (■) Goat (Kebridehar), (■) Goat (Shilavo).

Table 4: Differences in element concentrations of milk in cow, camel, and goat (mg/L).

Metals	Cow		Camel		Goat	
	Kebridehar	Shilavo	Kebridehar	Shilavo	Kebridehar	Shilavo
Magnesium	4.594 ± 0.036	4.833 ± 0.014	3.567 ± 0.092	3.625 ± 0.039	5.811 ± 0.019	6.325 ± 0.233
Calcium	1.417 ± 0.417	2.250 ± 0.417	1.160 ± 0.000	1.217 ± 0.012	1.776 ± 0.063	1.983 ± 0.109
Potassium	7.001 ± 0.019	5.959 ± 0.042	7.274 ± 0.266	7.105 ± 0.026	6.052 ± 0.475	6.376 ± 0.1252
Sodium	6.647 ± 0.109	6.652 ± 0.016	6.560 ± 0.012	7.751 ± 0.066	8.625 ± 0.044	8.401 ± 0.038
Manganese	1.350 ± 0.029	0.987 ± 0.046	<BDL	<BDL	1.417 ± 0.417	<BDL
Copper	0.673 ± 0.016	0.284 ± 0.016	0.876 ± 0.073	0.673 ± 0.016	0.723 ± 0.037	0.830 ± 0.0016
Cadmium	0.212 ± 0.059	0.565 ± 0.059	0.212 ± 0.058	0.506 ± 0.117	0.029 ± 0.006	0.065 ± 0.0058
Chromium	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Zinc	1.417 ± 0.097	1.660 ± 0.048	1.757 ± 0.048	1.466 ± 0.048	1.369 ± 0.048	1.272 ± 0.146
Lead	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL

Note: BDL=Below detection limit.

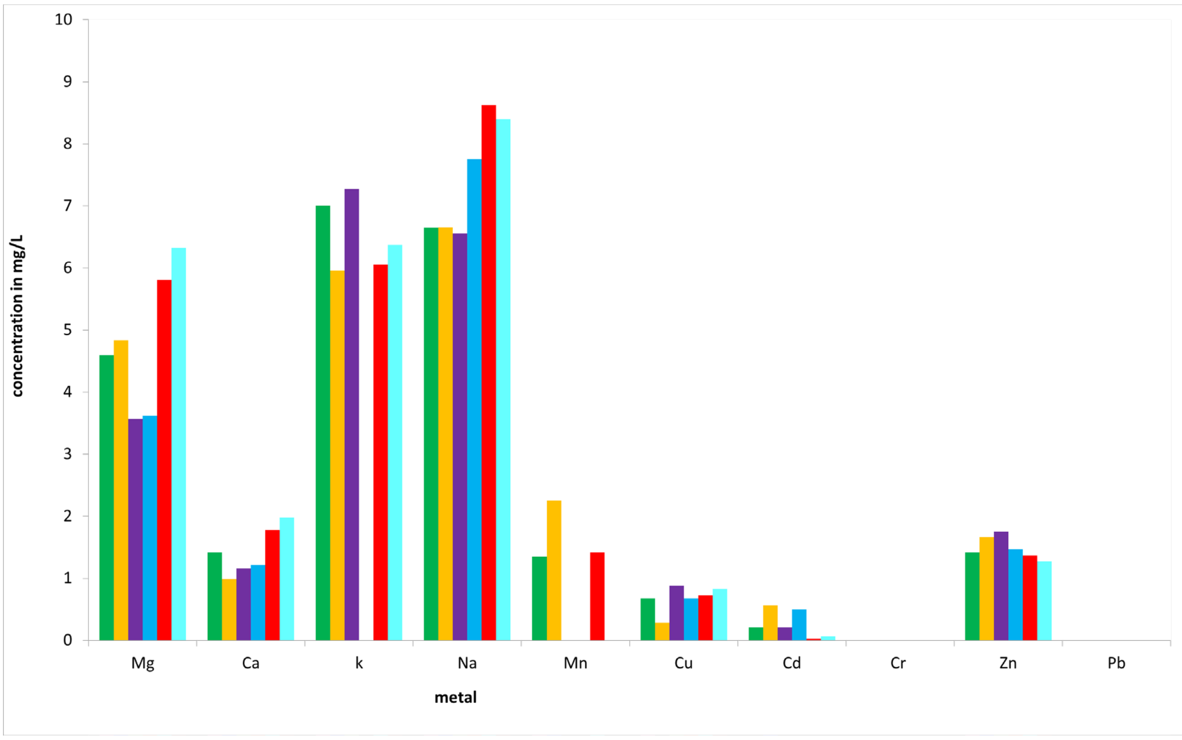

Figure 3: Histogram for comparisons of metals in cow, camel for the studied sites. **Note:** (■) Cow (Kebridehar), (■) Cow (Shilavo), (■) Camel (Kebridehar), (■) Camel (Shilavo), (■) Goat (Kebridehar), (■) Goat (Shilavo).

Concentration magnesium

The mean concentration of Mg in all samples of different animals is given in the Table 4. The mean concentration of Mg in cow, camel and goat milk of both studied areas did not vary significantly; however, a significant difference was observed between the Mg concentrations of cow camel, and goat milk ($p<0.05$). Goat milk was higher as compared to cow and camel milk. The Mg concentration in animals' milk was in the order of goat>cow>camel. In present study the Mg residues in the milk of goats (6.325 ± 0.233 mg/L) lower than in the goat milk (92.5 ± 12.0 µg /g) in China [62], in Guzo (140 ± 14.1) and Malta (141 ± 20.2) [63], in Pakistan (139 ± 15.7) [49]. The Mg content of cow milk in our study were greater than Mg content of cow milk reported by Nnadozie et al., in Nigeria (1.38 ± 0.16) [64].

Concentration of calcium

The highest Ca concentration (2.250 ± 0.417 mg/L) was in milk of cow of Shilavo and lowest concentration (1.160 ± 0.000 mg/L) in camel milk of Kebridehar. All the values in the Ca concentration in milk samples was in the order of cow>goat>camel. The Ca concentration in cow of this study was greater than the Ca concentration of cow (0.68 ± 0.08) reported by Nnadozie et al., in Nigeria [63] and lower than cow (680 ± 79.8 mg/L) reported by Imran et al., in Pakistan [49], and also the Ca concentration of our study in camel were lower than the concentration of camel in China (888 ± 358 reported by Lu Chen, et al., [62]. The ca concentration of goat milk in our study were lower than goat milk (644 ± 76.6 mg/L) reported by Imran et al., in Pakistan [49], Malta (922 ± 92.6) and Guzo (926 ± 90.3) [63] and Sudan (520 ± 115) [65].

Concentration of potassium

The highest K concentration (7.274 ± 0.266 mg/L) was found in milk of camel of Kebridehar and lowest concentration (5.959 ± 0.042 mg/ L) in the milk of cow of Shilavo. All the values in the study samples were below the permissible limit 2000 mg/kg. The K concentration in cow milk of Kebridehar and camel milk of both areas is almost in agreement but the Ca concentration in cattle milk of our study is lower than the reported results in china [62], Nigeria [64], and for goat in Pakistan [49] and Malta and Guzo [63].

Concentration of sodium

The highest Na concentration (7.274 ± 0.266 mg/L) was found in the milk of camel and lowest concentration (5.959 ± 0.042 mg/ L) in the milk of cow. All the results in the studied samples were below the permissible limit 500 mg/kg. The Na concentration in cow milk of Kebridehar and camel milk of both area is almost in agreement but the Na concentration in cattle milk was in the order of camel>cow of Kebridehar>goat. In this study the Na concentration of goat is lower than Na concentration of Goat in Pakistan and China [49,62].

Concentration of manganese

The milk of a goat from Kebridehar had the highest Mn concentration (1.417 ± 0.417 mg/L) and the milk of a cow from Shilavo had the lowest (0.987 ± 0.046 mg/L). All of the results in the study samples were higher than the 0.2 mg/kg acceptable limit. Our investigation found that the Mn concentration in cow, camel, and goat milk was higher than that reported by Ahmad et al., in Pakistan in which cow (0.056 ± 0.038 mg/kg), camel

(0.094 ± 0.003), and goat (0.065 ± 0.032 mg/kg) [66], and for cow in Bangladesh (0.126 ± 0.02) [67]. Manganese is a co-factor of the mutase antioxidant enzyme, but excessive amounts can cause health problems such as decreased neurological and neuromuscular control, as well as mental and emotional issues [9,62].

Concentration of copper

The highest concentration of copper in this study was observed in milk of camel (0.876 ± 0.073) and goat (0.830 ± 0.0016 mg/L). Cow milk had the lowest (0.284 ± 0.016 mg/L) and exactly the same concentration of Cu of cow in Kebridehar and camel of Shilavo (0.67 ± 0.016) mg/L were obtained. The Cu concentration in cow milk was also lower than the reported result in Egypt (2.836) [68], almost the same with the reported result in Tanzania [69]. But higher than other studied results like in Bangladesh (0.064 ± 0.013) [67], Egypt (0.142 ± 0.116) [6], Sudan (0.124) [65]. Some metals in lower concentrations are essential to maintain proper metabolic activity in living organisms. Cu is vital for the formation of proteins. It also has anti-oxidant properties and involved in the regulation of gene expression. However, excess copper leads to toxicity which consequently results into leads to conditions associated with deficiency of ceruloplasmin [70].

Concentration of cadmium

The highest cadmium value was found in the milk of cow of Shilavo (0.565 ± 0.059 mg/L) and the lowest value (0.029 ± 0.006 mg/L) was in milk of goat of Kebridehar. The remaining other samples showed very much less variations amongst each other. The Cd concentration in milk was in the order of cow>camel>goat. The WHO permissible limit for cadmium has been reported as 0.58 mg/kg [66]. Therefore, the concentration of cadmium in this study was in almost agreement with the permissible limit.

Concentration of chromium and lead

The Cr concentration was found in the milk is below the detection limit. The same results in lead were reported in the same animal species in Pakistan by Ahmad et al., [66]. The concentration of Pb in milk may result from consumption of contaminated feeding stuffs and the commonly used underground water in the redistricts. Pb has no beneficial biological function and is known to accumulate in the body. Pb exposure can cause adverse health effects, especially in young children and pregnant women. Pb is a neurotoxin that permanently interrupts normal brain development [71]. Maximum allowable limits from WHO is 0.05 mg/kg.

Concentration of zinc

Camel milk had the highest zinc concentration (1.757 ± 0.048 mg/L) while goat milk had the lowest result (1.272 ± 0.146 mg/L). The mean Zn concentration in milk of cow obtained in this study (1.417 ± 0.097-1.660 ± 0.048) was lower than that reported in Egypt, Nigeria, and previous value reported in Ethiopia [72,73].

CONCLUSION

This study's objectives were to assess a few physicochemical parameters and provide background data on the detrimental consequences and potential health risks of low-quality milk. The World Health Organization (WHO) set permitted limits for the concentration of metals was also taken into consideration during the investigation. The study emphasizes the significance of 10 metals concentrations in milk from cows, camels, and goats from Kebridehar and Shilavo, including Mg, Na, K, Ca, Cd, Cr, Cu, Mn and Zn. The research found that camel milk contained high levels of K (7.274 and 7.105 mg/L, respectively), but the concentration of Mn was Below detection limit (BDL). All samples have BDL levels of Cr and Pb as well. The goat milk in both study areas had the lowest concentration of Cd (0.029 ± 0.006) and the greatest concentration of Na (8.625 ± 0.044 and 8.401 ± 0.038), respectively, and is below the WHO limit (0.58). The concentration of the majority of the metals investigated in this study's milk samples were not in agreement with WHO limit (Cr (1.61), Cu (24.2 mg/L), Mn (55.5), and Zn (121 mg/L). A majority of highly toxic metals, like lead and copper, were not found in the samples, and some important minerals, like calcium, potassium, sodium, zinc, copper, and chromium, did not exceed their permissible limits, with the exception of Mn and Cd in cow and goat milk, which were slightly above the permissible limit. The results suggest that camel, cow, and goat milk may be safe to consume. Deficiency, however, could also be harmful because some of these vital minerals fall below the daily consumption threshold while still being necessary for regular physiological bodily functions. We recommend that the public officials and governmental organizations use this information to check the quality of milk products in the Kebridehar and Shilavo districts.

COMPETING INTERESTS

The authors declare no conflict of interest.

AUTHOR' S CONTRIBUTIONS

MB: formal analysis, investigation, methodology; AM: corresponding author, conceptualization; data curation, methodology, writing, original draft, GG: formal analysis, editing; investigation, KM: formal analysis, data curation. All authors reviewed the manuscript.

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