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Research Article

Quality Characteristics and Sensory Evaluation of Market Camel Milk Collected from Hyderabad, Pakistan

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Abstract | The present study was designed to check the physical, chemical and sensory characteristics of market camel milk, sold in the Hyderabad city. A total of 30 samples were collected and divided into 5 groups, i.e., S0 (control "fresh milk" taken directly from camel), S1 (Shop no.1), S2 (Shop no.2) S3 (Shop no.3) and S4 (Shop no.4). The conductivity (mS/cm) of S1 (7.27), S2 (7.22), S3 (7.49) and S4 (7.94) was significantly ($p < 0.05$) high to that of control group (5.82). The pH value of all groups i.e., S1 (6.02), S2 (5.74), S3 (5.84) and S4 (6.23) was significantly ($p < 0.05$) lower to that of control S0 (6.56). The specific gravity of S2 (1.022) was found significantly ($p < 0.05$) decreased to that of S0 (1.029), S1 (1.027) and S3 (1.026). The titratable acidity % was recorded significantly ($p < 0.05$) higher in S2 (0.25) than rest of the groups (0.16-0.18). Significantly ($p < 0.05$) low values of the viscosity (cP) were noted in S4 (1.69) group as compared to S0 (1.96), and S1 (1.95). In the context of chemical analysis, the percent moisture content of S1, S2, S3 and S4 was observed 89.40, 90.40, 89.93 and 90.26 respectively which were significantly ($p < 0.05$) elevated compared to S0 (88.35). The protein content of control (2.99), and S1 (2.97) was found significantly ($p < 0.05$) higher than that of S2 (2.53), S3 (2.67) and S4 (2.52) groups. Similarly, the fat content of S2 (2.10) was significantly ($p < 0.05$) lower than that of control (3.02). It was concluded that the conductivity and titratable acidity of the camel milk were observed higher, while pH, specific gravity and viscosity were noticed lower in the samples of different shops, compared with control (fresh milk). Chemically, the higher moisture and lower total solid content were observed in the camel milk collected from shops (S1 to S4) in comparison to freshly collected camel milk (S0). Overall highest acceptability score with nutritive values was perceived in S0 than all other groups.

Keywords | Camel, Market milk, Physical characteristics, Chemical characteristics.

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INTRODUCTION

Milk from different mammals is a significant source of all the vital nutrients necessary for mammals, including humans (Yang et al., 2019). Among these, the camel has the potential for addition in the food chain, as it is the source of milk, meat and by-products to serve millions of people especially in arid, semi-arid, mountainous and desert areas (Faraz et al., 2013). Pakistan provides a wide market for both a live export trade and a milk and meat industry dependent on camels, with a camel population of 1.2 million heads (Khan et al., 2016). In our country, about 873 tons of camel milk is being produced per annum which shares 1.7 % in total milk production (Gul et al., 2015). The largest camel herd size in the Pakistan is found in Baluchistan, followed by Punjab, Sindh

and Khyber Pakhtunkhwa provinces (Hussain et al., 2013). The camel is a vital source of food and means of transport. Camel milk has been used as a medicine for various diseases since ancient times against diabetes and cancer (Alavi et al., 2017; Ayoub et al., 2018). The daily milk yield ranges in dromedaries from 3 to 20 kg per day during the 12 to 18-month lactation period (Gizachew et al., 2014). Camel may produce additional milk for a longer period of time in arid zones and in harsh locations than any other domestic livestock species (Faraz et al., 2019c). Camel milk, also known as "white gold from the desert," is differentiated from other ruminant milk by its low cholesterol and sugar content, high mineral content (sodium, potassium, iron, copper, zinc, and magnesium), vitamin C, and protein (lactoferrin, lactoperoxidase, immunoglobulin, and lysozyme) (Yadav et al., 2015; Khalesi et. al., 2017). The camel milk has long been thought to be a treatment for a number of illnesses, including dropsy, jaundice, antihypertension, asthma, and leishmaniasis (kala-azar) (Asresie and Yusuf, 2014; Yadav et al., 2015). The milk from camel has also been reported to contain insulin-like and defensive proteins used to treat many diseases, such as diabetes, autism, diarrhoea, and has anti-tumor properties (Gul et al., 2015; Hussain et al., 2021). Market milk quality is one of the country's major problem, causing not only economic losses but also health consequences for the customers. It is therefore, the current study was planned to evaluate the quality characteristics and sensory evaluation of the market camel milk sold in the Hyderabad city.

MATERIALS AND METHODS

Milk sampling

A total of 30 samples of milk were collected from five different locations of Hyderabad city. The milk samples were divided into five groups, i.e., S0 (control; "fresh milk" taken directly from camel), S1 (Shop 01), S2 (Shop 02) S3 (Shop 03) and S4 (Shop 04), each group comprised of 6 samples. The sampling was done on the same day; however replication was carried out on the weekly basis. All the milk samples were transported (under chilled conditions; 4^{0}C) for further study purposes to the Animal Products Technology Laboratory, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University Tandojam.

Physical analysis of camel milk

The conductivity of the samples was measured by using a conductivity meter (Hanna Instruments, Italy) as per procedure of Tsuchiya et al. (2020). A sufficient amount of milk was taken into a beaker and the electrodes of conductivity meter were submerged in milk, before the results were obtained. The pH of the samples was measured directly using a pH meter (Hanna Instruments, Italy). In a beaker, an appropriate quantity of milk sample was taken. The pH meter electrodes were calibrated with pH 4.0 and 7.0 buffer solutions and the electrodes were submerged in the milk. The values after pH stabilization were then noted (Memon et al., 2018). The refractive index of commercial camel milk was specifically observed using a refractometer (ATAGO, Co., Ltd., Tokyo, Japan). A few drops of milk samples were mounted on the refracto-meter lens and the reading was then measured from the meter screen (Memon et al., 2018).

The precise gravity of the camel milk samples was measured using a pycnometer (Pyrex Co., USA) according to the methods used by Association of Official Analytical Chemist (AOAC, 2000). The density was measured by comparison of the distilled water density to obtain the specific gravity of the samples. Initially, water (at 20°C) was filled into the pre-weighed pycnometer and weight was registered. The same pycnometer was then refilled with a milk sample afterwards and the final weight was weighed. The relevant specific gravity was then determined after these values were obtained by the following formula:

$$Specific\ Gravity = \frac{wt.\ of\ milk\ sample}{wt\ of\ distilled\ water}$$

The titratable acidity percentage of the milk samples was assessed by the previously used method of Association of Official Analytical Chemists (AOAC, 2000). The milk samples were titrated with N/10 NaOH solution; where phenolphthalein (3-5 drops) was used as an indicator. The volume of alkali used was noted and finally it was calculated by using following formula:

$$Titratable\ acidity\ (\%) = \frac{Volume\ of\ 0.1\ N\ NaOH\ used \times 0.009}{Volume\ of\ the\ sample\ taken} \times 100$$

The sampled milk viscosity was calculated by using the Ostwald viscometer (Brookfield Engineering Laboratories, USA) with a uniform bore at 20°C, as defined by AOAC (2000). The flow time of the same amount of milk sample and water were calculated. The viscosity of the samples was then measured by given formula:

$$Viscosity\ (cP) = \frac{Flow\ time\ of\ milk\ at\ 20°C \times Specific\ gravity\ of\ milk}{Flow\ time\ of\ water\ at\ 20°C \times Specific\ gravity\ of\ water}$$

Chemical analysis

As defined by the AOAC, the humidity content was observed according to the procedure adopted by AOAC (2000). The milk samples (5g) were transferred to a pre-weighted flat bottom dish. The dish was then moved for 3 hours in a hot air oven at 101 ± 1°C temperature and then was kept on a silica gel desiccator for one hour. The humidity was then calculated by given formula.

$$\text{Moisture (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where, W1 = weight of empty dish, W2 = weight of dish + sample, W3 = weight of dish + weight of dried sample

Using Gerber methodology, the fat content of the samples was calculated as formerly described by James (1995). In short, the milk sample (11ml) was mixed in a butyrometer (Funke Gerber, Berlin, Germany) with 90 percent sulfuric acid (10ml) and amyl alcohol (1ml), and the mixture was then locked with a rubber plug. The butyro-meter was put in the Gerber machine and then centrifuged at 11000 rpm for 3 minutes. The percentage of fat was noted on the butyro-meter scale.

The protein content of the samples was determined by using the British Standards Institution (BSI) method 1990. In the presence of a catalyst (0.2g copper sulphate and 2.0g sodium sulphate), in the Micro-Kjeldhal digester milk sample (5g), sulfuric acid (30ml) was used as an oxidizing agent. Digested milk samples were then diluted with the help of distilled water (250ml). Diluted samples were then distilled with 40% NaOH using the Micro-Kjeldhal distillation unit, where steam was distilled for 3-5 minutes over 2% boric acid (5ml) consisting of an indicator (Bromocresol green). Finally, by titration with 0.1N HCl, trapped ammonia in boric acid was determined. The nitrogen percentage was calculated using the following formula:

$$\text{N (\%)} = \frac{1.4 \times (V1\text{-}V2) \times \text{Normality of HCL}}{\text{Weight of sample taken} \times \text{Volume of diluted sample}} \times 250$$

V1=Titrated value of milk sample
V2= Titrated value of blank sample

By translating the nitrogen percentage into protein, the protein content was determined, assuming that all the nitrogen content in milk was present as protein. To measure the total protein content in milk, the obtained percentage of nitrogen was multiplied by the conversion factor, i.e. 6.38 (BSI, 1993).

To determine the ash content of the samples, a gravimetric method described by AOAC (2000) was used. Milk samples (5g) were moved to the muffle furnace (550 °C) for 4-5 hours of ignition and then transferred to silica gel desiccator for 1 hour. The crucibles were then weighed and the ash content was measured by using the formula.

$$\text{Ash (\%)} = \frac{\text{Wt. of Ash}}{\text{Wt. of Sample}} \times 100$$

Lactose content of milk samples were determined by difference method using following formula:
Lactose (%) = TS % - (Fat% + Protein% + Ash %)

The sensorial quality of the milk samples was calculated using the Hedonic 9 point scale as adopted in earlier studies (Magsi et al., 2021) while the nutritive value was calculated as per procedures of AOAC (2000).

Statistical Analysis

Student Edition of Statistix (SXW), Version 8.1, was used to conduct the statistical analysis (Copyright 2005, Analytical software-USA). The data was tabulated in excel and analysed using a mathematical formula for summary statistics, which showed that there was heterogeneity within the same milk character across different samples. The data was further analysed using linear models, which included an analysis of variance with a factorial design and in the event of a significant difference, a mean of least significant difference (LSD) test at a probability level of 0.05 (%).

RESULTS

Physical Characteristics

The camel milk was analyzed for the conductivity of different milk shops and freshly obtained samples (control). The average conductivity of S0, S1, S2, S3, and S4 was recorded as 5.82, 7.27, 7.22, 7.49 and 7.94 respectively. The analysis showed that the conductivity of the milk was higher in all marketed samples than that of control groups. However, non-significant (p>0.05) difference was observed among all marketed groups (Table 1).

The influence of pH of the milk samples of different groups was observed, the average pH value of control (S0) was recorded as 6.56, while in S1, S2, S3, and S4 it was 6.02, 5.74, 5.84 and 6.23, respectively. Statistical Analysis of variance (ANOVA) showed that the pH value significantly varied among all groups. While computing the least significant difference (LSD 0.05), it was observed that pH value of control S0 (6.56) was significantly higher (p <0.05) than that of S1 S2 S3 and S4 groups of milk samples (Table 1). The results of refractive index of the milk samples; fresh and from different shops were observed statistically similar showed non-significant (p >0.05) results. i.e., control (S0) was 1.34 although in others (S1, S2, S3 and S4) it was 1.34, 1.34, 1.34 and 1.36 (Table 1).

The average specific gravity of control (S0) and shop (S1, S2, S3, and S4) samples were 1.02 and 1.03, 1.02, 1.03 and 1.02 respectively. Statistically, it was observed that specific gravity of control S0 (1.02) was significantly (p <0.05) higher than that of S2 (1.02) and S4 (1.02) while non-significant with S1 and S3. It is also observed that the S1 and

Table 1: Physical characteristics of market camel milk.

Physical Characteristics	Camel milk Samples (groups)					P<0.05	
	S0	S1	S2	S3	S4	LSD (0.05)	±SE
Conductivity (mS/cm)	5.82^{b}	7.27^{a}	7.22^{a}	7.49^{a}	7.94^{a}	0.825	0.400
Refractive Index (μ)	1.345^{a}	1.345^{a}	1.343^{a}	1.344^{a}	1.360^{a}	0.021	0.010
pH	6.56^{a}	6.02^{c}	5.74^{d}	5.84^{d}	6.23^{b}	0.150	0.073
Specific gravity	1.029^{a}	1.027^{ab}	1.022^{c}	1.026^{ab}	1.024^{bc}	3.21E-03	1.56E-03
Titratable Acidity (g/L)	0.160^{b}	0.185^{b}	0.251^{a}	0.183^{b}	0.160^{b}	0.035	0.017
Viscosity (mPa·s)	1.968^{a}	1.956^{a}	1.846^{ab}	1.871^{ab}	1.698^{b}	0.247	0.120

S0 = Control (fresh), S1 = shop 01, S2 = Shop 02, S3 = Shop 03, S4 = Shop 04

Different superscript on same row shows significant difference (p<0.05)

Table 2: Chemical characteristics of market camel milk

Chemical Characteristics	Camel milk Samples (groups)					P<0.05	
	S0	S1	S2	S3	S4	LSD (0.05)	±SE
Moisture content (%)	88.35^{b}	89.40^{a}	90.40^{a}	89.93^{a}	90.26^{a}	0.010	0.490
Fat content (%)	3.02^{a}	2.83^{ab}	2.10^{b}	2.56^{ab}	2.36^{ab}	0.676	0.370
Protein content (%)	2.99^{a}	2.97^{a}	2.53^{b}	2.67^{ab}	2.52^{b}	0.396	0.192
Lactose content (%)	4.51^{a}	3.73^{a}	4.06^{a}	3.83^{a}	3.87^{a}	0.992	0.482
Ash content (%)	1.12^{a}	1.06^{a}	0.90^{a}	1.00^{a}	0.96^{a}	0.233	0.113

S0 = Control (fresh), S1 = shop 01, S2 = Shop 02, S3 = Shop 03, S4 = Shop 04

Different superscript on same row shows significant difference

S3 were non-significant (p >0.05) with each other (Table 1).

Acidity percentage from different groups was examined, and the high (p <0.05) acidity (%) in the S2 (0.25), fol lowed by S1 (0.19), S3 (0.18) and S4 (0.16) was observed in comparison to that of control (0.16). Statistically non-significant difference observed in all groups except S2 sample. Whereas LSD (p >0.05) showed the no significant difference among the shop samples, i.e. S1, S3 and S4 compared to that of control (S0) group (Table 1).

The average viscosity of the control (S0) was noted as 1.96 followed by S1, S3, S2 and S4 (1.95, 1.87, 1.85 and 1.69 respectively). Statistically, the viscosity of S0 (1.96) and S1 (1.95) was significantly (p <0.05) different from S4 (1.69) while S2 (1.84), S3 (1.87) and S4 (1.69) showed non-significant (p >0.05) with each other (Table 1).

Chemical characteristic

The average moisture content of raw milk (control-S0) was found 88.35%, whereas S1, S2, S3 and S4 was observed 89.40%, 90.40%, 89.93% and 90.26%; respectively (Table 2). It was noted that the moisture content of control group was lower and showed significant difference with rest of the samples, while S1, S2, S3 and S4 were non-significant (p >0.05) with each other.

The average fat content (Table 2) of control (S0) was higher 3.02% followed by S1, S3, S4 and S2 (2.83, 2.56, 2.36 and 2.10 respectively). However, the analysis of variance showed that there is non-significant difference among the S1, S2, S3 and S4 groups. While, only S2 group showed (p <0.05) lower fat content in comparison to control (S0). The average protein of control (S0) and shops samples (S1, S2, S3 and S4) were determined 2.99, 2.97, 2.53, 2.67 and 2.52 respectively (Table 2). Statistically, it was observed that the protein content of the control (2.99) was significantly (p <0.05) higher than that of S2 (2.53) and S4 (2.52), while, no statistical difference was seen in between S1 and S3.

The average lactose content of S0, S1, S2, S3 and S4 (Table 2) was recorded as 4.51, 3.73, 4.06, 3.83 and 3.87; respectively. The lactose of sampled milk was noticed lower in different groups than that of control group. However, the non-significant (p >0.05) difference was observed among shop groups.

This experiment has determined that the average ash content of the control (S0) was 1.12% followed by S1, S3, S4, and S2 (1.06%, 1.00%, 0.96 and 0.90% respectively). Statistically, the analysis of variance showed that there is non-significant (p >0.05) difference among all experimental groups, with slight raised values in the control (Table 2). High nutritive values (Figure 1) in the analyzed samples (Kcal/100ml) were found in the S0 (57.22) followed by S1 (52.30), S3 (49.10), S4 (46.90) and S2 (45.30). Statistical

analysis (ANOVA) revealed significant (p <0.05) difference, in the nutritive value of all groups, whereas LSD (p >0.05) showed no significant difference among the S2, S3 and S4 compared to that of control (S0) group.

The sensory quality of milk samples were tested by various attributes on Hedonic 9 point scale by panel of judges and the overall acceptability was described in Figure 2. The score for overall acceptability of fresh milk (S0), rated by the panel of judges was significantly (p <0.05) higher (8.16) than that of S2 (6.16), S3 (7.16) and S4 (6.50), while, no statistical difference (p >0.05) was established between S1 (7.33) and control.

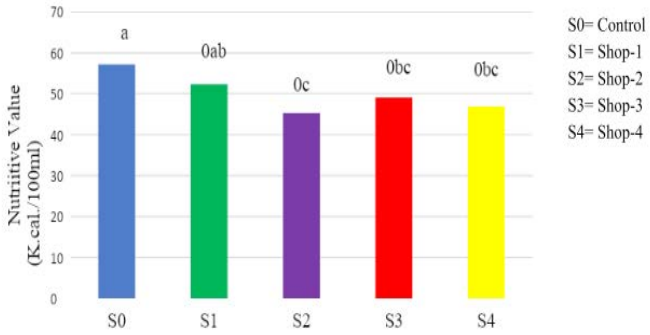

Figure 1: Nutritive value (K.cal./100ml) of fresh and market camel milk
S0 = Control (Fresh), S 1 = Shop 1, S2 = Shop 2, S3 = Shop 03, S4 = Shop 4
Different superscript labels given on the bars indicates significant (p<0.05) values among various groups.

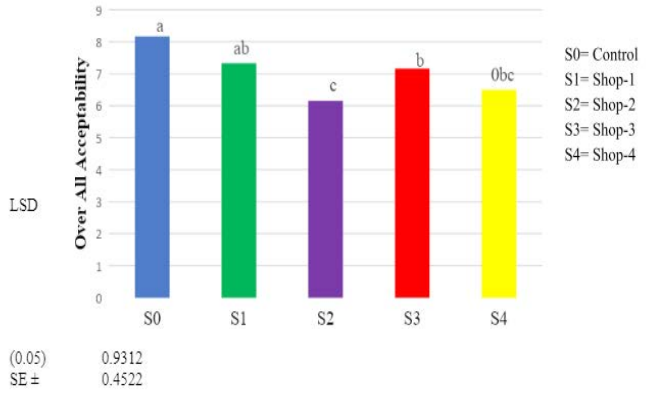

Figure 2: Over All Acceptability of fresh and market camel milk
S0 = Control (Fresh), S 1 = Shop 1, S2 = Shop 2, S3 = Shop 3, S4 = Shop 4
Different superscript labels given on the bars indicates significant (p<0.05) values among various groups.

DISCUSSION

Our study recorded many qualities of the camel milk sold at Hyderabad market for the quality assurance. We have observed that the conductivity of the milk samples was higher in the shops milk samples than that of control. The difference in electrical conductivity might be affected by iron and chloride concentration. Similarly, a higher electrical conductivity of the milk is caused by rise in sodium (Na+) and chloride (Cl-) content and a decrease in potassium (K+) and lactose content, as seen in water adulterated samples. Yoganandi et al. (2014) illustrated the mean electrical conductivity of the camel milk as 6.08, which is in close association with the milk sample of our control group.

Market camel milk was analyzed for the pH, and our results showed that the average pH value of control samples was higher than all other experimental groups. The decrease in pH values of all marketed samples might be due to the period of milk stored in shop or because of unhygienic of milking and the preservation technique for marketing. The results of our control group are in agreement with Gul et al. (2015), who reported that, the pH of camel milk ranges from 6.2-6.5. The corresponding pH values of the camel milk have also been determined by Khaskheli et al. (2005). The mean refractive index of the camel milk has been reported 1.34 by Yoganandi et al. (2014). Correspondently, our results showed that the refractive index of the control/ fresh (S0) and the shops samples. Refractive index is related to the adulteration of milk with oil and dissolved SNF contents.

The specific gravity of the market camel milk samples (S1, S2, S3, and S4) and control (S0) were in agreement with the stated results of Mint et al. (2011), who found the specific gravity of camel milk ranged between 1.02-1.03. The high level of water content leads low specific gravity reported by Khaskheli et al. (2005). The adulteration of water might deviate the specific gravity of milk.

The titratable acidity of sample S2 of this study was noted significantly higher (p>0.05) than that of control samples, while, the milk samples S1, S3 and S4 were found to be similar for acidity to that of control milk sample. In contrast, Mal et al. (2007) reported the acidity of fresh camel milk is 0.12% ± 0.03%. This variation might be due to inversely proportional relationship of acidity with pH values by formation of lactic acid from lactose or because of storage at freezing temperature to preserve market milk for a longer period.

The viscosity of fresh milk samples and market samples was observed relatively similar in all experimental samples with exception of S4 (1.69). Less viscosity was noted in S4 in contrast to control and S1 might be due to evaporation of moisture that indirectly enhances the proportion of total solids in milk. Kherouatou et al. (2003) observed the vis-

cosity 1.72 mPa of the camel milk, who also suggested that it depends on the increase in fat and SNF.

In present study the chemical characteristics; like moisture, fat, protein, lactose and ash contents of fresh camel milk (control) and of various market samples were analyzed. The moisture content of the fresh camel milk was noted markedly lower compared to that of shop-1, 2, 3 and 4, while, no statistical difference was established among the market samples for moisture content. The results fall under range of moisture content in the camel milk as reported by others researcher's findings showed the range 84-91% (Kneuss, 1984; Sisay F, et al., 2015). Moreover, the high moisture in market samples against fresh might be the result of water adulteration that is common practice in the market milk.
The results of current study shows, that the fat content of the fresh camel milk was observed significantly higher than market samples. Kahskheli et al. (2005) reported the fat content in camel milk is ranged between 2.8 to 5.0 %, these values are consistent with our experimental results. Similarly, the dromedary camel milk fat reported by different researchers was 2.9 to 5.4% Haddadin et al. (2008) and Konuspayeva et al. (2009). The variations in fat content directly proportional with the total solids content of the camel milk, i.e. if total solids increased, the fat content will be enhanced and vice versa.

The present study showed the protein percent of the fresh milk was higher than that of sold in the market. In contrast average 2.54 ± 0.19 protein percent was reported by (Khaskheli et al., 2005; Gizachew et al., 2014) in fresh camel milk, these values are lower than that of our findings. The variation in protein content of fresh camel milk might be due to different feeding, milking interval and amount of total solids, which differ in various seasons of weather. The feed and water intake can directly affects the protein content and quality of milk (FAO, 1982).

The lactose content was found in the milk samples of all tested groups with no statistical difference. The slight variation might be due to camel grazing, usually on halophillic plants (e.g. Atriplex, Acacia). Our results are in association with Kanhal and Hamad (2010), Khaskheli et al. (2005) who reported the lactose content (%) of the camel milk within the range of 3.3 to 4.4, 2.9 to 4.1 respectively.

The ash content in fresh milk (1.12%) was noted slightly raised than sold in the market. It is interested to note the reason for slight variation in ash content may be free grazing of camel on bushes or the plants grown at saline soil. On other hand current results are in agreement with observation found by Khaskheli et al. (2005), who reported that the ash content of camel milk ranged from 0.85 to 1.0 (average 0.94 ± 0.02).

The nutritive values obtained by pre-calculated formula showed that the values of fresh milk samples were higher than that of stored market milk. In the light of these results it is suggested that the nutritive value of milk depends on its constituents; if total solids and components were higher the nutritive value will also be augmented.

The sensory evaluation of sampled camel milk, judged by panelist showed the overall acceptability. The score for overall acceptability of control samples were good in comparison to market milk. The sensory scored results of our experimental samples were good to very good according to AOAC (2000). Furthermore, Ahmed et al. (2014), who reported overall acceptability scores of the camel milk ranges between 6.4 - 7.0.

CONCLUSIONS

It is to be concluded that, the conductivity and titratable acidity of the camel milk were observed higher, and pH, specific gravity and viscosity were found lower in the samples of different shops, compared with control. Chemically, the higher moisture and lower total solid content were observed in the camel milk sold in the market versus to control. Nutritive value of S0 and S1 was found higher compared to that of other groups. On the basis of results further studies are being suggested; study could be conducted in order to observe adulterants and their effects on quality characteristics of market camel milk. Experiments should also be carried out on microbial quality of the market camel milk.

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CONFLICT OF INTEREST

All Authors declared that; there is no conflict of interest.

AUTHORS CONTRIBUTION

Shah AH and Khaskheli GB designed the experiment, Korejo RA Conducted the experiment and collected the Data. Rajput MN, Korejo NA, analysed the data, Kalwar Q and Jalbani YM wrote the manuscript. Magsi AS, Khand FM helped in proof reading of manuscript.

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