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COMPARISON OF PHYSICO-CHEMICAL PROPERTIES OF CAMEL MILK WITH COW MILK AND BUFFALO MILK

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ABSTRACT

The comparison was made between various physico-chemical properties of camel milk with cow and buffalo milk. The mean acidity in camel milk was 0.144% lactic acid. Similarly, in cow milk and buffalo milk, it was 0.136% and 0.133% lactic acid, respectively. The mean specific gravity of camel milk was 1.029. Similarly, in cow and buffalo milk, the mean specific gravity was 1.029 and 1.033, respectively. The specific gravity of camel milk was significantly lower than that of the buffalo milk. The viscosity of camel milk was significantly higher than that of the cow milk but lower than buffalo milk. The mean surface tension of camel milk was 58.39 dyne/cm. Similarly, in cow and buffalo milk, the mean specific gravity was 51.77 dyne/cm and 50.78, dyne/cm, respectively. The mean refractive index of camel, cow and buffalo milk was value 1.3423, 1.3459 and 1.3464, respectively. The freezing point of camel milk was -0.518°C which was higher than the cow and buffalo milk. The electrical conductivity of camel milk was significantly higher than the cow as well as buffalo milk.

Key words: Acidity, camel milk, electrical conductivity, freezing point, specific gravity, viscosity

Camel milk is known for its medicinal properties, which are widely exploited for human health, as in several countries from the ex-Soviet Union (Kenzhebulat *et al*, 2000) and developing countries (Mal *et al*, 2006). In the western world, camel milk is experiencing a novel awareness in these days and even the FAO has stepped in promoting camel milk (Ramet, 2001). Camel milk is considered to have anti-cancer (Magjeed, 2005), hypo-allergic (Shabo *et al*, 2005) and anti-diabetic properties (Agrawal *et al*, 2003). A high content in unsaturated fatty acids contributes to its overall dietary quality (Karray*et al*, 2005; Konuspayeva *et al*, 2008). In arid and semi-arid areas where cows are affected by the heat and lack of water and feed, Camelids play a major role in supplying milk in these areas.

There are available references on camel milk, regarding production (Konuspayeva *et al*, 2009) or composition/physico-chemical properties (Farah, 1993; Ramet, 1993). The chemical and technological characteristics of camel milk are different from that of cow and buffalo milk. Publications dealing with the physico-chemical properties of camel milk are relatively scarce and much of the information is approximate and fragmental. Much of the work so far, has been carried out by the individuals with little institutional support. Thus, the research has tended to remain isolated with little impact on dairy camel production (Farah, 1993). However, different researchers have reported different values of camel milk based on their research.

Therefore, there is a need to undertake systematic study to generate data. In dairy industry, study for physico-chemical properties of milk is generally carried out to secure data. The data on the physical properties of milk are useful for designing dairy equipment, determination of constituents, detection of adulteration in milk, assessing quality of milk and assisting in several dairy operations.

Therefore, in the present study the basic physico-chemical properties of camel (*Camelus dromedarius*) milk viz. acidity, specific gravity, viscosity, surface tension, refractive index, freezing point and electrical conductivity were studied and its comparison were carried out with cow and buffalo milk.

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Materials and Methods

The pooled milk samples of camel milk from Anand and Kheda districts (8), cow milk (8) and buffalo milk (8) were collected from the herd of cows and buffaloes from Gopalpura village of Anand district between November 2010 to March 2013. The samples were kept in ice and transported to the laboratory, where these were stored at 4°C. Milk samples were collected in clean and dry sample bottles and kept at refrigeration temperature before its analysis. Total 24 samples (8 each) were analysed for physico-chemical properties. The gross chemical composition of camel, cow and buffalo milk samples were analysed as per the method described in BIS Handbook (SP 18: part XI, 1981).

Physico-chemical parameters of milk

Titratable acidity of all the milk samples was determined as per the standard procedure. Specific gravity/density of the milk sample by specific gravity bottle procedure. The viscosity of all the milk samples were determined using Ostwald viscometer. The Surface tension of all the milk samples was determined by using Stalagmometer. Refractive index was determined using Abbe refractometer in all the milk samples (BIS Hand book, SP18, Part XI, 1981). Freezing point of camel, cow and buffalo milk were analysed by ultrasonic eko milk analyser (Everest Instruments Pvt. Ltd, Vishnagar, India). Electrical conductivity of camel, cow and buffalo milk were analysed by ultrasonic eko milk analyser (BIS Hand book, SP18, Part XI, 1981).

The data obtained during investigation were subjected to statistical analysis using completely randomised design (Snedecor and Cochran, 1967).

Result and Discussion

The collected samples of camel milk were analysed for various physico-chemical properties and simultaneously cow and buffalo milk were also analysed for its comparison. The average total solid contents in camel, cow and buffalo milk were 12.74%, 13.74% and 15.19%, respectively. The average fat content in camel, cow and buffalo milk was 4.68%, 5.02% and 6.10% whereas, solid-not-fat content was 8.04%, 8.64% and 9.07%, respectively.

Acidity

The natural acidity in milk is due to its constituents such as casein, albumin, citrates, phosphates and carbon dioxide. On the other hand, developed acidity is due to formation of lactic acid from lactose by microbial activity. In practical work both did not distinguish from each and determined together by titrating milk against a standard alkali using phenolphthalein as an indicator. In the present investigation, acidity of all 3 milk samples of camel, cow and buffalo were determined by titration method. Total 8 replications were conducted. The data obtained for acidity of camel, cow and buffalo milk along with their statistical analysis are presented in table 1.

The average of acidity in camel milk was 0.144% lactic acid. Similarly, in cow milk and buffalo milk, it was 0.136 and 0.133% lactic acid, respectively. The difference in acidity of camel milk and that of the cow and buffalo milk was statistically significant. The acidity of camel milk was significantly higher than that of the cow milk and buffalo milk.

Raghvendar *et al* (2004) reported 0.154% lactic acid and pH 6.3–6.6 in Indian camel milk. Abu-Lehia (1987) analysed milk samples of Najdi camels for a period of 3 months during winter/spring season and stated that titratable acidity was 0.15% lactic acid. Karim and Gooklani (1987) reported 0.21% lactic acid in Turkman Sahara camel milk.

Table 1. Mean ± SEM of acidity of milk.

Type of milk	Acidity (% lactic acid)
Camel	0.144±0.003
Cow	0.136±0.003
Buffalo	0.133±0.003
SEM	0.0030
CD (0.05%)	0.0089
CV %	6.284

SEM: Standard error of mean; CD: Critical difference (5% level significant); CV: Coefficient of variance

Park *et al* (2007) reported 0.15-0.18% lactic acid in cow milk. A study was conducted on the physico-chemical properties of crossbred (HF × Deoni). The mean values of individual milk samples for acidity was 0.131% lactic acid. The same parameter observed for herd milk samples was 0.139% lactic acid (Bin *et al*, 2003).

Sindhu (1998) reported that buffalo milk has higher acidity due to 0.16% lactic acid at 20°C as compared to the values of cow milk as 0.15% lactic acid. Aneja *et al* (2002) found that acidity in cow and buffalo was due to 0.15 and 0.16 per cent lactic acid, respectively.

The data obtained in present study for average acidity of camel milk was very well in agreement with those reported in the literature for milk obtained from dromedary camel in India. The data are also in general agreement with those reported for camel milk obtained from exotic dromedary camel at abroad acidity of camel milk. Similarly, the data obtained for average acidity of cow milk were also in general agreement with those reported in the literature for cow milk. However, in present study, buffalo milk was found to contain lower acidity compared to camel milk as well as cow milk. In fact the pattern of low acidity in buffalo milk as compared to cow milk is also generally observed during the practical classes conducted in this laboratory.

Specific gravity

The data obtained for specific gravity are presented in table 2.

Table 2. Mean ± SEM of specific gravity of milk.

Type of milk	Specific gravity
Camel	1.029±0.000
Cow	1.029±0.000
Buffalo	1.033±0.000
SEM	0.000286
CD (0.05%)	0.000841
CV %	0.0785

SEM: Standard error of mean; CD: Critical difference (5% level significant); CV: Coefficient of variance

The mean of specific gravity of camel, cow and buffalo milk was 1.029, 1.029 and 1.033, respectively. The buffalo milk had the highest specific gravity, which was followed by cow milk and camel milk. The specific gravity of camel milk was significantly lower than that of the buffalo milk. However, difference in specific gravity of camel and cow milk was statistically non-significant.

Khanna and Rai (1993) observed that the specific gravity of Indian camel milk was 1.030. EI-Erian (1979) reported that the milk of camels grazing near Riyadh (Saudi Arabia) had specific gravity between 1.028 to 1.038. lqbal (1999) found it to be 1.030 in camels.

An average content of specific gravity was 1.0317-1.0380 in buffalo milk (Hanl *et al*, 2012). The mean value for specific gravity in Marathwadi buffalo milk was 1.031 ± 0.001 (Padghan *et al*, 2008). Sindhu (1998) reported that buffalo milk has higher specific gravity 1.0323 at 20°C compared to the respective values of cow milk as 1.0317 at 20°C. Park *et al* (2007) reported specific gravity as 1.0231-1.0398 in cow milk.

The data obtained in present study for mean specific gravity of camel milk was in general agreement with those reported in the literature for milk obtained from dromedary camel in India and exotic breeds. Similarly, the data obtained for mean specific gravity of cow and buffalo milk were also in general agreement with those reported in the literature for cow and buffalo milk, respectively.

Viscosity

The data obtained for viscosity of all the 3 types of milk along with their statistical analysis are presented in table 3.

Table 3. Mean ± SEM of viscosity of milk

Type of milk	Viscosity (cp)
Camel	1.77±0.016
Cow	1.54±0.021
Buffalo	1.79±0.023
SEM	0.0219
CD (0.05%)	0.064
CV %	3.64

SEM: Standard error of mean; CD: Critical difference (5% level significant); CV: Coefficient of variance

The mean viscosity of camel milk was 1.77 cp. Similarly, in cow and buffalo milk, the mean specific gravity was 1.54 cp and 1.79 cp, respectively. The viscosity of camel milk was significantly higher than that of the cow milk but lower than that of buffalo milk. However, difference in viscosity of camel milk and that of the buffalo milk was statistically non-significant.

One of the important factors significantly affecting viscosity of milk is fat. The effect of fat greatly depends upon the clustering of fat globules. The high viscosity of camel milk may be attributed to the persence small flocules like particles. Camel milk was reported to have high viscosity (El-Naggar, 1998).The viscosity of camel milk is 1.72 mpas at 20°C, whereas, the viscosity of bovine milk at the same dry matter content and under the same conditions is 2.04 mpas (Kherouatou *et al*, 2003). A mean value for viscosity of Egyptian camel milk was 2.2 mpas, which is higher than the mean value of 1.8 mpas for cow milk (Hassan *et al*, 1987). Laxminarayana and Dastur (1968) reported that viscosity of cow milk was 1.86 cp. whereas, in buffalo milk it was 2.04 cp. Sindhu (1998) reported that buffalo milk had higher viscosity 2.245 cp at 27°C as compared to the values of cow milk as 1.450 cp at 27°C. The viscosity in cow and buffalo milk was 1.450 cp and 2.245 cp at 27°C, respectively (Aneja *et al*, 2002).

The data obtained in present study for average viscosity of camel milk was in general agreement with those reported in the literature for camel milk.

Similarly, the trend obtained for mean viscosity of cow and buffalo milk were also in general agreement with those reported in the literature for cow and buffalo milk, respectively.

Surface tension

The data obtained for surface tension of all 3 types of milk along with their statistical analysis are presented in table 4.

Table 4. Mean ± SEM of surface tension of milk.

Type of milk	Surface tension (dyne/cm)
Camel	58.39±0.421
Cow	51.77±0.184
Buffalo	50.78±0.259
SEM	0.3257
CD (0.05%)	0.9579
CV %	1.72

SEM: Standard error of mean; CD: Critical difference (5% level significant); CV: Coefficient of variance

The mean of surface tension of camel milk was 58.39 dyne/cm. Similarly, in cow and buffalo milk, the mean specific gravity was 51.77 dyne/cm and 50.78 dyne/cm, respectively. The surface tension of camel milk was significantly higher than that of the cow milk as well as buffalo milk.

Casein and whey protein are powerful depressant of surface tension. The protein-phospholipids complex is the most powerful depressant of the surface tension. They significantly, depress the surface tension of milk (Watson, 1958). Therefore, higher surface tension of camel milk may be attributed to its low fat and protein content.

From review of literature it appears that no data reported in literature regarding surface tension of camel milk. Sindhu (1998) reported that buffalo milk has higher surface tension (45.50 dynes/cm at 20°C) as compared to the values of cow milk as 42.50 dynes/cm at 20°C. Laxminarayana and Dastur (1968) reported that surface tension of cow and buffalo milk was 55.9 and 55.4 dynes/cm, respectively. The surface tension in cow and buffalo milk were 42.50 and 45.50 dynes/cm at 20°C, respectively (Aneja *et al*, 2002). Park *et al* (2007) reported 42.3-52.1 dynes/cm as surface tensions in cow milk. Data were not available in the literature for surface tension of camel milk.

Refractive index

The data obtained for refractive index of all the 3 types of milk along with their statistical analysis are presented in Table 5.

Table 5. Mean ± SEM of refractive index of milk

Type of milk	Refractive index
Camel	1.3423±0.001
Cow	1.3459±0.000
Buffalo	1.3464±0.000
SEM	0.0056
CD (0.05%)	0.00167
CV %	0.1195

SEM: Standard error of mean; CD: Critical difference (5% level significant); CV: Coefficient of variance.

The mean refractive index of camel milk was value 1.3423. Similarly, in cow and buffalo milk, the mean refractive index was 1.3459 and 1.3464 respectively. The buffalo milk had the highest refractive index which was followed by cow milk and the lowest refractive index was found in camel milk. The refractive index of camel milk was significantly lower than that of the buffalo milk as well as cow milk.

Refractive index of milk depends upon dissolved solids present in it. The lower refractive index of camel milk may be attributed to its low SNF content.

Data were not available in literature regarding refractive index of camel milk. Park *et al* (2007) reported 1.451±0.35 refractive index in cow milk. Refractive index of cow milk was 1.3338 whereas, in buffalo milk it was 1.3448 as reported by (Laxminarayana and Dastur, 1968). The refractive index of milk fat varies from 1.4537 to 1.4552 at 50°C and it is used to indicate its purity (Aneja *et al*, 2002).

Freezing point

The data obtained for freezing point of all the 3 types of milk along with their statistical analysis are presented in table 6.

Table 6. Mean ± SEM of freezing point of milk.

Type of milk	Freezing point (°C)
Camel	-0.518±0.001
Cow	-0.530±0.003
Buffalo	-0.540±0.006
SEM	0.0044
CD (0.05%)	0.0131
CV %	2.390

SEM: Standard error of mean; CD: Critical difference (5% level significant); CV: Coefficient of variance

The average of freezing point of camel milk was -0.518°C. Similarly, in cow and buffalo milk, the average freezing point was -0.530°C and -0.540°C respectively. The freezing point of camel milk was significantly higher than that of the cow milk as well as buffalo milk. Freezing point of milk depends upon dissolved solids present in it. The lower freezing point of camel milk may be attributed to its low SNF content.

Only one report is available in the literature regarding freezing point of camel milk. Wangoh (1997) reported that the freezing point of camel milk was between -0.57°C and -0.61°C. The freezing point of cow and buffalo milk (0.530°C and -0.5454°C, respectively) were observed by Aneja *et al* (2002). Park *et al* (2007) reported -0.530 to -0.570°C freezing point in cow milk. Laxminarayana and Dastur (1968) reported that freezing point depression of cow and buffalo milk was 0.570 and 0.560, respectively.

The value obtained in present study for average freezing point of camel milk was lower than that reported in the literature for camel milk. However, the trend for freezing point of cow and buffalo milk was in general agreement with those reported in the literature for cow and buffalo milk, respectively.

Electrical conductivity

The data obtained for electrical conductivity of all the 3 types of milk along with their statistical analysis are presented in table 7.

Table 7. Mean ± SEM of electrical conductivity of milk.

Type of milk	Electrical conductivity (millimohs)
Camel	6.08±0.057
Cow	4.60±0.072
Buffalo	4.65±0.031
SEM	0.0596
CD (0.05%)	0.1753
CV %	3.30

SEM: Standard error of mean; CD: Critical difference (5% level significant); CV: Coefficient of variance

The mean electrical conductivity of camel milk was 6.08 mmho. Similarly, in cow and buffalo milk, the mean electrical conductivity was 4.60 mmho and 4.65 mmho, respectively. The camel milk had the highest electrical conductivity, followed by buffalo milk and lowest electrical conductivity found in cow milk. The electrical conductivity of camel milk was significantly higher than that of the cow milk as well as buffalo milk.

Electrical conductivity is affected by concentration of irons present in the milk. In milk about 60 to 80% of the current carried by Na+, K+, and Cl- (Schulz and Sydow, 1957). Khaskheli *et al* (2005) observed the range between 0.20 to 0.28 g per 100 gm camel milk. Therefore, high electrical conductivity attributed may be due to high chloride content.

Data were not available in the literature regarding electrical conductivity of camel milk. Park *et al* (2007) reported 0.0040-0.0050 (Ω-1cm-1) electrical conductivity of cow milk. A study was conducted on the physico-chemical properties of crossbreed (HF × Deoni). The mean value of individual milk samples for electrical conductivity was 4.704 millimohs. The same parameters observed for herd milk samples was 4.672 millimohs (Bin *et al*, 2003). Aneja *et al* (2002) observed that electrical conductivity in cow and buffalo milk were 4.00 to 5.50 mmoh/cm and 3.22 to 6.67 mmoh/cm, respectively.

Khaliq *et al* (2001) conducted bacteriological studies on raw milk supplied to Faisalabad city during summer months and reported electrical conductivity 2.2 to 2.9 µmoh/cm in 44% samples, 3.3 to 3.9 µmoh/cm in 45% samples and 4.0 to 4.5 µmoh/cm in 9% buffalo milk samples.

Data were not available in the literature for electrical conductivity of camel milk.

Conclusion

The present study concluded that the camel milk has significantly high acidity, viscosity, surface tension, freezing point, electrical conductivity whereas, the specific gravity and refractive index of camel milk was significantly lower than that of the buffalo milk. The specific gravity of camel milk and that of the cow milk was statistically non-significant but viscosity of camel milk was significantly higher than that of the cow. These parameters would be useful in formulation of various milk products from camel milk as well as in designing of various processed equipment.

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