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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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A Comparative Study on the Physicochemical Parameters of Milk Samples Collected from Buffalo, Cow, Goat and Sheep of Gujrat, Pakistan

Asif Mahmood and Sumaira Usman
Department of Chemistry, University of Gujrat, Gujrat, Pakistan

Abstract: This research work was carried out to compare the physicochemical parameters of milk samples of four different species like buffalo, cow, goat and sheep. Milk samples were collected from the different areas of Gujrat, Pakistan and analyzed for different physiochemical parameters, including pH, specific gravity, titratable acidity, total solids, ash, fat, protein and lactose. It was recorded that buffalo milk had 6.75±0.15 pH, 1.033±0.002 specific gravity, 0.21±0.03% titratable acidity, 18.45±0.85% total solids, 0.81±0.09% ash, 7.97±0.44% fat and 4.36±0.23% protein and 5.41±0.54% lactose. Cow milk had 6.64±0.02 pH, 1.029±0.001 specific gravity, 0.17±0.02% titratable acidity, 12.94±0.97% total solids, 0.60±0.13% ash, 4.00±0.43% fat, 3.37±0.32% protein and 4.51±0.38% lactose. Goat milk had 6.55±0.06 pH, 1.030±0.001 specific gravity 0.16±0.01% titratable acidity, 12.84±0.56% total solids, 0.75±0.13% ash, 3.97±0.51% fat, 3.15±0.32% protein and 4.39±0.34% lactose. Sheep milk contained 6.63±0.04 pH, 1.034±0.002 specific gravity, 0.23±0.01% titratable acidity, 18.13±0.21% total solids, 0.88±0.07% ash, 6.49±0.23% fat, 5.30±0.29% protein and 4.77±0.31% lactose. All the tested parameters were higher in buffalo and sheep milk than cow and goat milk.

Key words: Physicochemical parameters, buffalo milk, cow milk, goat milk, sheep milk, Gujrat

INTRODUCTION

Milk, which is the secretion of the mammary glands, is the only food of the young mammal during the first period of its life. The substances in milk provide both energy and the building materials necessary for growth. Milk also contains antibodies which protect the young mammal against infection (Bylund, 1995). Milk plays a tremendous role in building a healthy society and can be used as vehicle for rural development, employment and slowing down the migration of the rural population (Sarwar *et al*., 2002).

In the year 2008-2009, Pakistan produced 43,562 million tons of milk; of which 62.04% was contributed by buffaloes, 34.39% by cows, 1.65% by goats, 0.08% by sheep and 1.83% by camels (Anonymous, 2009).

Buffalo is the most valuable animal and is being highly liked by the people of the sub-continent. Buffalo milk is preferred more than the cow's milk (Bilal *et al*., 2006). Buffalo milk is a valuable nutrient with high content of milk proteins, lipids, vitamin and other biologically active substances (Mikailoglu *et al*., 2005).

Cow have contributed greatly to human welfare, supplying draft power, milk, meat, hides, fuel and a variety of other products (Hodgson, 1979). Cow's milk has long been considered a highly nutritious and valuable human food and is consumed by millions daily in variety of products (Heeschen, 1994).

Goats play a special role in the life of smallholder farmers. Their small size makes it possible for farmers to keep a large herd in small area (Boylan *et al*., 1996). Goat has been referred as the "poor man's cow" due to his great contribution to the health and nutrition of the landless and rural poor (Dresch, 1988). Goat milk differs from cow or human milk in having better digestibility, alkalinity and buffering capacity (Park, 1994).

Sheep milk is an excellent raw material for the milk processing industry especially in cheese production (Park *et al*., 2007). Sheep milk has higher specific gravity, viscosity, refractive index, titratable acidity, and lower freezing point than average cow milk (Haenlein and Wendorff, 2006).

The aim of present study was to assess and compare the physicochemical parameters of milk samples collected from buffalo, cow, goat and sheep of Gujrat, Pakistan.

MATERIALS AND METHODS

Collection of samples: Forty fresh milk samples were collected in sterile bottles from four species like buffalo, cow, goat and sheep (ten milk samples of each species) of Gujrat, Pakistan. Milk samples after collection were brought to the Laboratory of Chemistry Department, University of Gujrat, Gujrat, Pakistan. Physicochemical analysis of milk samples was carried out in laboratory.

Physicochemical analysis: The pH was measured using a digital pH-meter (InolabWTW Series 720) calibrated with pH 4 and 7 buffers. Specific gravity was determined by using pycnometer as described by

Corresponding Author: Asif Mahmood, Department of Chemistry, University of Gujrat, Gujrat, Pakistan

AOAC (2000). Titratable acidity was determined by titrimetric method as described by AOAC (2000). Total solids content was determined according to the method of AOAC (2000). Ash content was determined by gravimetric method using a muffle furnace at 550°C as described by AOAC (2000). Fat content was determined by Rose-Gottlieb method as described by AOAC (2000). Protein content was estimated by formal titration method (Davide, 1977). Lactose content was determined by using Fehling's solution method (Triebold, 2000).

Statistical analysis: The statistical analysis was carried out using SPSS program (Statistical Package for Social Sciences version 16). The significant differences between means were calculated by one-way Analysis of Variance (ANOVA) using Tukey range test.

RESULTS AND DISCUSSION

pH: pH of milk samples collected from different species was determined at the time of sampling. The values of pH of milk samples of different species are shown in Table 1. The results showed that pH values were in the range of 6.53-7.00 in buffalo milk, 6.59-6.67 in cow milk, 6.48-6.64 in goat milk and 6.55-6.68 in sheep milk. pH values of buffalo milk were significantly ($p<0.05$) higher than that of cow and sheep milk. pH values of goat milk were lower than that of buffalo milk at a highly significant ($p<0.001$) level. The results showed that pH values of milk sample collected from cow, goat and sheep were non-significantly ($p>0.05$) different from each other.

pH values found in buffalo milk were in accordance with the findings of Braun and Stefanie (2008), Kanwal *et al.* (2004) and Imran *et al.* (2008). pH values found in cow milk were in agreement with the findings of Kanwal *et al.* (2004) and Enb *et al.* (2009). pH values of goat milk were similar to that reported by Sawaya *et al.* (1984). pH values of sheep milk were similar to that reported by Kurkdjian and Gabrielian (1962); Haenlein and Wendorff (2006).

Specific gravity: Specific gravity of milk samples collected from buffalo, cow, goat and sheep is given in Table 2. Specific gravity was found in range of 1.030-1.035 in buffalo milk, 1.027-1.031 in cow milk, 1.028-1.032 in goat milk and 1.032-1.037 in sheep milk.

Specific gravity of buffalo milk was higher than that of cow and goat milk at highly significant ($p<0.001$) level. Specific gravity of sheep milk was also higher than that of cow and goat milk at highly significant ($p<0.001$) level. There was non-significant ($p>0.05$) difference between the specific gravity of buffalo and sheep milk, cow and goat milk.

The specific gravity of buffalo milk was similar to the findings of Franciscis *et al.* (1988). The specific gravity of cow milk was similar that cited by Jenness *et al.* (1974).

Table 1: pH values of milk samples collected from buffalo, cow, goat and sheep

	pH values			
Source of milk	Min.	Max.	Mean	SD(±)
Buffalo	6.53	7.00	6.75	0.15
Cow	6.59	6.67	6.64	0.02
Goat	6.48	6.64	6.55	0.06
Sheep	6.55	6.68	6.63	0.04
Significance				
Buffalo milk v/s Cow milk	*			
Buffalo milk v/s Goat milk	***			
Buffalo milk v/s Sheep milk	*			
Cow milk v/s Goat milk	n.s			
Cow milk v/s Sheep milk	n.s			
Goat milk v/s Sheep milk	n.s			

Significance: *** = $p<0.001$, * = $p<0.05$, n.s = $p>0.05$,
Min. = Minimum, Max. = Maximum, SD = Standard Deviation

Table 2: Specific gravity of milk samples collected from buffalo, cow, goat and sheep

	Specific gravity			
Source of milk	Min.	Max.	Mean	SD(±)
Buffalo	1.030	1.035	1.033	0.002
Cow	1.027	1.031	1.029	0.001
Goat	1.028	1.032	1.030	0.001
Sheep	1.032	1.037	1.034	0.002
Significance				
Buffalo milk v/s Cow milk	***			
Buffalo milk v/s Goat milk	***			
Buffalo milk v/s Sheep milk	n.s			
Cow milk v/s Goat milk	n.s			
Cow milk v/s Sheep milk	***			
Goat milk v/s Sheep milk	***			

Significance: *** = $p<0.001$, n.s = $p>0.05$,
Min. = Minimum, Max. = Maximum, SD = Standard Deviation.

The specific gravity of goat milk was in accordance with that reported by Juarez and Ramos (1986). The specific gravity of sheep milk was quietly similar to that reported by Kurkdjian and Gabrielian (1962); Haenlein and Wendorff (2006). Specific gravity of sheep milk high was due to its high content of solids-non-fat.

Titratable acidity: The values of titratble acidity of milk samples collected from buffalo, cow, goat and sheep are given in Table 3. It was observed from results that the values of titratble acidity were in the range of 0.17-0.26% in buffalo milk, 0.14-0.19% in cow milk, 0.14-0.18% in goat milk and 0.21-0.26% in sheep milk.

The values of titratable acidity of buffalo milk were higher than that of cow and goat milk at highly significant ($p<0.001$) level. The values of titratable acidity of sheep milk were also higher than that of cow and goat milk at highly significant ($p<0.001$) level. It was observed that difference in the values of titratable acidity in buffalo and sheep milk was significant ($p<0.05$). Difference between the values of titratable acidity of cow and goat milk was non-significant ($p>0.05$).

Table 3: Titratable acidity of milk samples collected from buffalo, cow, goat and sheep

	Titratable acidity (%)			
Source of milk	Min.	Max.	Mean	SD(±)
Buffalo	0.17	0.26	0.21	0.03
Cow	0.14	0.19	0.17	0.02
Goat	0.14	0.18	0.16	0.01
Sheep	0.21	0.26	0.23	0.01
Significance				
Buffalo milk v/s Cow milk	***			
Buffalo milk v/s Goat milk	***			
Buffalo milk v/s Sheep milk	*			
Cow milk v/s Goat milk	n.s			
Cow milk v/s Sheep milk	***			
Goat milk v/s Sheep milk	***			

Significance: *** = p<0.001, * = p<0.05, n.s = p>0.05,
Min. = Minimum, Max. = Maximum, SD = Standard Deviation.

Table 4: The concentration of total solids in milk samples collected from buffalo, cow, goat and sheep

	Total solids (%)			
Source of milk	Min.	Max.	Mean	SD(±)
Buffalo	16.99	20.18	18.45	0.85
Cow	11.23	14.26	12.94	0.97
Goat	12.00	13.73	12.84	0.56
Sheep	17.94	18.53	18.13	0.21
Significance				
Buffalo milk v/s Cow milk	***			
Buffalo milk v/s Goat milk	***			
Buffalo milk v/s Sheep milk	n.s			
Cow milk v/s Goat milk	n.s			
Cow milk v/s Sheep milk	***			
Goat milk v/s Sheep milk	***			

Significance: *** = p<0.001, n.s = p>0.05,
Min. = Minimum, Max. = Maximum, SD = Standard Deviation.

The values of the titratable acidity in buffalo milk were in accordance with the findings Rehman and Salaria (2005). The values of titratable acidity in cow milk were in line with that reported by Enb *et al.* (2009) and Mahboba and Zubeir (2007). The titratable acidity values of goat milk were similar to the findings of Sawaya *et al.* (1984). The values of titratable acidity of sheep milk were similar to that reported by Kurkdjian and Gabrielian (1962), Haenlein and Wendorff (2006). Acidity of milk is due the presence of lactic acid, citric acid and phosphoric acid (Bylund, 1995).

Total solids: The concentration of total solids in milk samples collected from buffalo, cow, goat and sheep is given in Table 4. These results illustrated that the concentration of total solids was in range of 16.99-20.18% in buffalo milk, 11.23-14.26% in cow milk, 12.00-13.73% in goat milk and 17.94-18.53% in sheep milk.
The concentration of total solids in buffalo milk was higher than that in cow and goat milk at highly significant (p<0.001) level. The concentration of total solids in sheep milk was also higher than that in cow and goat milk at highly significant (p<0.001) level. Statistical analysis showed non-significant (p>0.05) difference between the concentration of total solids in buffalo and sheep milk, cow and goat milk.
The concentration of total solids found in the buffalo milk was similar to that reported by Zaman *et al.* (2007), Braun and Stefanie (2008) and Bei-Zhong *et al.* (2007). The concentration of total solids found in cow milk during this investigation was in line with the findings of Imran *et al.* (2008), Enb *et al.* (2009) and Mahboba and Zubeir (2007). The concentration of total solids found in goat milk was similar to that reported by Kanwal *et al.* (2004) and Imran *et al.* (2008). The concentration of total solids found in sheep milk was similar to the findings of Talevski *et al.* (2009).

Ash: Ash content in milk samples collected from buffalo, cow, goat and sheep is given in Table 5. The results of this study revealed that the ash content was in the range of 0.69-0.98% in buffalo milk, 0.40-0.80% in cow milk, 0.56-0.99% in goat milk and 0.78-0.98% in sheep milk. Amount of ash content in cow milk was lower than that in buffalo and sheep milk at highly significant (p<0.001) level. There was significant difference (p<0.05) between the amount of ash content in cow and goat milk. There was non-significant (p>0.05) difference between the amount of ash content in the milk samples collected from buffalo, goat and sheep.
Amount of ash content found in buffalo milk was in agreement with that reported by Enb *et al.* (2009), Khan *et al.* (2007), Imran *et al.* (2008) and Bei-Zhong *et al.* (2007). Amount of ash content found in cow milk was in accordance with that reported by Enb *et al.* (2009) and Imran *et al.* (2008). Amount of ash content found in goat milk during this study was in line with the findings of Bhosale *et al.* (2009) and Keskin *et al.* (2004). Imran *et al.* (2008) reported higher ash content in goat milk. Ash content found in sheep milk during this research work was similar to that reported by Adewumi and Olorunnisomo (2009) and Bylund (1995).

Fat: Fat content in milk samples collected from buffalo, cow, goat and sheep is given in Table 6. Results illustrated that fat content was in the range of 6.99-8.41% in buffalo milk, 3.44-4.96% in cow milk, 3.16-4.73% in goat milk and 6.09-6.80% in sheep milk.
The amount of fat content in buffalo milk was higher than that in the milk of other species at highly significant (p<0.001) level. The amount of fat content in sheep milk was higher than that in milk of cow and goat but lower than that in buffalo milk at highly significant (p<0.001) level. There was non-significant (p>0.05) difference between the amount of fat content in cow and goat milk. Fat content found in buffalo milk was in accordance with that reported by Khan *et al.* (2007). Fundora *et al.* (2001) reported lower fat content in buffalo milk than present investigation. Amount of fat content in cow milk was in

Table 5: Ash content in milk samples collected from buffalo, cow, goat and sheep

	Ash (%)			
Source of milk	Min.	Max.	Mean	SD(±)
Buffalo	0.69	0.98	0.81	0.09
Cow	0.40	0.80	0.60	0.13
Goat	0.56	0.99	0.75	0.13
Sheep	0.78	0.98	0.88	0.07
Significance				
Buffalo milk v/s Cow milk	***			
Buffalo milk v/s Goat milk	n.s			
Buffalo milk v/s Sheep milk	n.s			
Cow milk v/s Goat milk	*			
Cow milk v/s Sheep milk	***			
Goat milk v/s Sheep milk	n.s			

Significance: *** = p<0.001, * = p<0.05, n.s = p>0.05,
Min. = Minimum, Max. = Maximum, SD = Standard Deviation.

Table 6: Fat content in milk samples collected from buffalo, cow, goat and sheep

	Fat (%)			
Source of milk	Min.	Max.	Mean	SD(±)
Buffalo	6.99	8.41	7.97	0.44
Cow	3.44	4.96	4.00	0.43
Goat	3.16	4.73	3.97	0.51
Sheep	6.09	6.80	6.49	0.23
Significance				
Buffalo milk v/s Cow milk	***			
Buffalo milk v/s Goat milk	***			
Buffalo milk v/s Sheep milk	***			
Cow milk v/s Goat milk	n.s			
Cow milk v/s Sheep milk	***			
Goat milk v/s Sheep milk	***			

Significance: *** = p<0.001, n.s = p>0.05,
Min. = Minimum, Max. = Maximum, SD = Standard Deviation.

Table 7: Protein content in milk samples collected from buffalo, cow, goat and sheep

	Protein (%)			
Source of milk	Min.	Max.	Mean	SD(±)
Buffalo	4.01	4.78	4.36	0.23
Cow	2.98	3.87	3.37	0.32
Goat	2.38	3.48	3.15	0.32
Sheep	4.56	5.50	5.30	0.29
Significance				
Buffalo milk v/s Cow milk	***			
Buffalo milk v/s Goat milk	***			
Buffalo milk v/s Sheep milk	***			
Cow milk v/s Goat milk	n.s			
Cow milk v/s Sheep milk	***			
Goat milk v/s Sheep milk	***			

Significance: *** = p<0.001, n.s = p>0.05,
Min. = Minimum, Max. = Maximum, SD = Standard Deviation.

Table 8: Lactose content in milk samples collected from buffalo, cow, goat and sheep

	Lactose (%)			
Source of milk	Min.	Max.	Mean	SD(±)
Buffalo	4.56	6.21	5.41	0.54
Cow	4.01	5.00	4.51	0.38
Goat	3.70	4.88	4.39	0.34
Sheep	4.37	5.22	4.77	0.31
Significance				
Buffalo milk v/s Cow milk	***			
Buffalo milk v/s Goat milk	***			
Buffalo milk v/s Sheep milk	**			
Cow milk v/s Goat milk	n.s			
Cow milk v/s Sheep milk	n.s			
Goat milk v/s Sheep milk	n.s			

Significance: *** = p<0.001, ** = p<0.01, n.s = p>0.05,
Min. = Minimum, Max. = Maximum, SD = Standard Deviation.

line with the findings of Kanwal *et al*. (2004), Samia *et al*. (2009) and Mahboba and Zubeir (2007). Lingathurai *et al*. (2009) reported higher fat content in cow milk. Amount of fat content found in goat milk during this investigation was similar to that cited by Strzalkowska *et al*. (2009) and Bhosale *et al*. (2009). Amount of fat content found in sheep milk during this research work was lower than that reported by Adewumi and Olorunnisomo (2009), Talevski *et al*. (2009) and Pavic *et al*. (2002).

Protein: Protein content in milk samples collected from buffalo, cow, goat and sheep is given in Table 7. According to these results protein content was in range of 4.01-4.78% in buffalo milk, 2.98-3.87% in cow milk, 2.38-3.48% in goat milk and 4.56-5.50% in sheep milk. The amount of protein content in sheep milk was higher than that in the milk of other species at highly significant (p<0.001) level. The amount of protein content in buffalo milk was higher than that in the milk of cow and goat but lower than that in sheep milk at highly significant (p<0.001) level. There was non-significant (p>0.05) difference between the amount of protein content in cow and goat milk.

It was observed that protein content found in buffalo milk was in accordance with the findings of Imran *et al*. (2008). Higher protein content in buffalo milk was reported by Braun and Stefanie (2008) and Fundora *et al*. (2001). Protein content in cow milk was in line with the findings of Imran *et al*. (2008), Enb *et al*. (2009) Mahboba and Zubeir (2007) and Samia *et al*. (2009). Protein content found in goat milk during this investigation was similar to the findings of Strzalkowska *et al*. (2009) and Aneja *et al*. (2002). Protein content found in sheep milk during this research work was lower than that reported by Pavic *et al*. (2002). The reduction might be due breed difference, health status of the udder and stage of lactation.

Lactose: Lactose content in milk samples collected from buffalo, cow, goat and sheep is given in Table 8. Results illustrated that the lactose content was in range of 4.56-6.21% in buffalo milk, 4.01-5.00% in cow milk, 3.70-4.88% in goat milk and 4.37-5.22% in sheep milk. The amount of lactose content in buffalo milk was higher than that in cow and goat milk at highly significant (p<0.001) level. By comparing lactose content of buffalo and sheep milk moderately significant (p<0.01)

difference was obtained. There was non-significant ($p>0.05$) difference between the amount of lactose content in cow, goat and sheep milk.

Lactose content found in buffalo milk was similar to that cited by Imran *et al.* (2008) and Khan *et al.* (2007). Lactose content found in cow milk during this research work was similar to the findings of Samia *et al.* (2009) and Lingathurai *et al.* (2009). Lactose content in goat milk was in accordance with that reported by Imran *et al.* (2008), Strzalkowska *et al.* (2009), Bhosale *et al.* (2009) and Sawaya *et al.* (1984). Lactose content in sheep milk was similar to that reported by Pavic *et al.* (2002) and Bylund (1995).

Conclusion: All the tested parameters were higher in buffalo and sheep milk than cow and goat milk. Specific gravity, titratable acidity, ash and protein in sheep milk were higher than that in buffalo milk but pH, total solids, fat and lactose in sheep milk were lower than that in buffalo milk. All the tested parameters were similar in cow and goat milk except ash which was higher in goat milk.

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