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Comparative Analysis of Quality of Milk Collected from Buffalo, Cow, Goat and Sheep of Rawalpindi/Islamabad Region in Pakistan

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Abstract: Milk is nearly complete food and contains all the essential components in nearly balanced form. In the present study, the milk of four different species like goat, cow, buffalo and sheep milk, was analyzed compositionally and results showed that the cow milk have highest LR and specific gravity i.e., 30.0 and 1.03, respectively than other three species i.e. buffalo, goat and sheep. The cow milk showed maximum pH value (6.65) while sheep milk samples showed maximum titratable acidity (0.181%). The minimum pH value (6.58) was of sheep milk while the minimum titratable acidity (0.15%) was of the cow milk samples. The results of fat (%) showed that buffalo, cow, goat milk are non-significantly different from each other but sheep milk is significantly different from other three species. However, the results of SNF found in this study showed significant difference ($P<0.05$) among the milk of buffalo (8.79%) and of goat milk (8.92%). In contrast, the SNF of milk samples obtained from cow and sheep (9.17 and 9.71%, respectively). The results showed that the sheep milk had the good range (5.32-7.74%) of protein and the highest average protein contents (6.57%). However the milk of cow (5.23%) and buffalo (3.87%) were significantly different from each other and from sheep milk. The milk of goat showed the lowest protein contents (2.38%) as compare to other species. Sheep milk has highest%age of total nitrogen (1.035) contents as compared to other three species and hence significantly different from them and in %age non-protein nitrogen values of sheep milk showed the highest value (0.0059) and goat milk showed the least value (0.0013). Sheep milk showed the lowest lactose contents (3.57%) while goat milk showed highest value (4.66%). Sheep milk had highest value (0.58%) of ash contents while the goat milk showed the lowest value (0.28%). Cow milk was found best according to this study as compared to the milk samples of other three species i.e. Buffalo, goat and sheep.

Key words: Milk comparison, compositional analysis, milk analysis, cow milk, buffalo milk, goat milk, sheep milk

INTRODUCTION

Milk is as ancient as mankind itself, as it is the substance created to feed the mammalian infant. All species of mammals, from man to whales, produce milk for this purpose. Many centuries ago, perhaps as early as 6000-8000 B.C, ancient man learned to domesticate species of animals for the provision of milk to be consumed by them. These included cows, buffaloes, sheep, goats and camels, all of which are still used in various parts of the world for the production of milk for human consumption[1]. Milk is the characteristic secretion of mammary gland of all mammals. Because of its function of the nourishment of the young, it is necessarily complex; it must supply nutrients, minerals and vitamins in proper form, kind and amount[2].

The annual gross milk production in Pakistan has been estimated as about 17.12 million-tone during the year 1992-93. It has been estimated that out of total milk production, 71% is produced by buffaloes, 24% by cattle and 5% by sheep and goats[3].

Milk is a very complex, naturally possessing many chemical and physical components. All milks contain the same kind of constituents but in varying amount. Within a given species, genetic factors and environmental conditions such as the climate and the stage of lactation influence the composition[2].

According to Malcolm and Paul[4] cow milk contains 12.5% total solids, 3.8% fat, 8.7% solid non fat, 4.6% lactose, 0.8% ash, 0.2% NPN (Non Protein Nitrogen), 3.1% protein and 87.5% water. Sheep's milk is higher in fat, protein, calcium and potassium than human or cow's milk[1]. The overall mean levels of total solids, fat, SNF, ash, protein, lactose and energy for goats were 17.4, 6.8, 10.6, 0.88, 4.5, 4.7% and 4.44 MJ kg^{-1}, respectively. The respective values for sheep were 18.3, 6.0, 12.3, 0.94, 5.2,

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4.9% and 4.39 MJ kg^{-1}[5]. Within each species, there are significant differences in compositional values between seasons.

According to West Pakistan Pure food rules[6] market milk shall contain not less than 3.5% fat and 8.5% solid non-fat (SNF). According to another report the legal standards of 5% butterfat and 10%SNF for unclassified market milk should be in force in Pakistan[7]. It was found that buffalo and cow milk of NARC dairy farms contain 6.5 and 16.6% and 3.8 and 12.8% fat and total solid, respectively[8].

Composition of milk is also strongly influenced by the breed of animals. It has been reported that breeds producing milk with a high fat content produce less milk than those with lower fat %age[9]. Milk composition also varies with the stages of lactation; during early stage of lactation that is colostral stage milk composition is considerably different. Colostrum is rich in antibodies and is different from normal milk in color and taste[10].

MATERIALS AND METHODS

Collection of milk samples: Total forty fresh milk samples, ten milk samples of each species were collected in sterile bottles by direct milking, from four different non-dairy species like goat, cow, buffalo and sheep milk, from Rawalpindi and Islamabad region:

Milk samples after collection were brought to the Dairy Technology Research Laboratory (DTRL) of Animal Sciences Institute, NARC, Islamabad, within 2-3 h. Each milk sample was analyzed for compositional analysis.

Physical and chemical analysis: Milk samples were analyzed both physically and chemically by following tests:

The lactometer is used as an aid in detecting milk to which water might have been added as describe by Lampert[11]. Lactometer reading and Specific Gravity is determine by Eckles *et al.*[10] method. Determination of pH

Fig. 1: Macro Kjeldhal distillation apparatus (for protein and NPN and TN analysis)

was done according to method describe by Anonymous[12]. Total titratable acidity was estimated by using Atherton and Newlander method[13]. Using method described by anonymous[14] did fat determination. Total solid contents were measured by using method described by Ling[15]. Determination of Protein was done by using Kjeldahl method[12] (Fig. 1). Estimation of Lactose was done by method describe by Patel and Mistry[16] and ash contents was determined by using Khalil and Manan method[17].

RESULTS AND DISCUSSION

Lactometer Reading (LR) and specific gravity: The results of LR and Specific gravity of all milk samples are shown in Table 1. The cow milk showed the highest LR and specific gravity i.e., 30.0 and 1.03, respectively. Similarly LR of buffalo's milk ranged 26.0 to 29.0 and corresponding to specific gravities of 1.026 to 1.029, respectively. Moreover, the milk of goat samples showed LR and specific gravity in the range of 27 to 30 with the corresponding specific gravities of 1.027 to 1.030, respectively. Further comparison of LR values, the Sheep milk samples showed LR and specific gravity in the range of 27 to 29 with the corresponding specific gravities of 1.027 to 1.029, respectively. These results showed that goat and sheep milk is non-significantly different but cow and buffalo milk is significantly different from each other. According to Lampert[11], the lactometer is used as an aid in detecting milk to which water might have been added. Normal milk rarely has a specific gravity (at 60°F) less than 1.030 (LR = 30) and therefore a lower lactometer reading would justify suspicion that the milk had been adulterated. The results of specific gravity are discussed in Table 1.The value of specific gravity of cow milk (1.03), which resembles the above-mentioned value, but the results of other three species (buffalo, goat and sheep) are quite different.

pH and total titratable acidity: pH and total titratable acidity of each milk sample were noted at fresh stage. The titratable acidity test is a simple acid-base reaction. This test allows a calculation of %age acidity in milk. The values for pH and %age titratable acidity in various milk samples are given in Table 2. The cow milk showed maximum pH value (6.65) while sheep milk samples showed maximum titratable acidity (0.181%). The minimum pH value (6.58) was of sheep milk while the minimum titratable acidity (0.15%) was of the cow milk samples. The results showed that buffalo, cow, goat milk are non-significantly different from each other but sheep milk is significantly different from all other three species. In case

Table 1: Lactometer Reading (LR) and Specific gravities of different milk samples

Source	LR (Range)	LR (Mean)	Sp. Gravities (Range)	Sp. Gravities (Mean)
Buffalo	26-29	27.65	1.02-1.02	1.02
Cow	28-34	30.0	1.02-1.03	1.03
Goat	27-30	28.65	1.02-1.03	1.02
Sheep	27-29	28.05	1.02-1.02	1.28

• Mean bearing the same letter are statistically not different from one another (P< 0.05)

Table 2 : Total Titratable Acidity (TTA) and pH of different milk samples

Sources	TTA (Range)	TTA (Mean)	pH (Range)	pH (Mean)
Buffalo	0.11-0.18	0.133	6.60-6.9	6.64
Cow	0.12-0.19	0.15	6.63-6.68	6.65
Goat	0.11-0.17	0.135	6.34-6.68	6.59
Sheep	0.16-0.19	0.181	6.40-6.80	6.58

• Mean bearing the same letter is statistically not different from one another (P< 0.05)

Table 3: Percentage Fat of different milk samples

Sources	% Fat (Average)	% Fat (Range)	Standard Deviation (SD)
Buffalo	5.25	4.0-6.5	0.96
Cow	4.56	4.0-5.0	0.41
Goat	4.73	3.9-5.7	0.63
Sheep	8.96	8.0-9.6	0.56

• Mean bearing the same letter are statistically not different from one another (P< 0.05)

Table 4: Percentage Total solids of different milk samples

Sources	%TS (Average)	%TS (Range)	Standard Deviation (SD)
Buffalo	14.04	12.73-15.90	1.19
Cow	13.73	13.43-14.34	0.28
Goat	13.55	12.60-15.17	0.80
Sheep	18.53	17.48-19.50	0.68

• Mean bearing the same letter are statistically not different from one another (P< 0.05)

Table 5: Percentage SNF of different milk samples

Sources	% SNF (Mean)	%SNF (Range)	Standard Deviation (SD)
Buffalo	8.79	8.28-9.40	0.32
Cow	9.17	8.43-10.14	0.49
Goat	8.92	8.53-9.47	0.29
Sheep	9.71	9.48-10.1	0.22

• Mean in the same column followed by the same letter are not statistically different (P<0.05)

Table 6: Percent protein contents of milk collected from different species

Sources	Protein (%) Mean	Range (%)	Standard Deviation (SD)
Buffalo	3.87	3.12-4.12	0.28
Cow	5.23	4.46-5.75	0.42
Goat	2.38	1.10-3.18	0.71
Sheep	6.57	5.32-7.74	0.89

• Mean in the same column followed by the same letter are not statistically different (P<0.05)

Table 7: Total nitrogen % of milk collected from different species

Sources	TN % (Mean)	Range (%)	Standard Deviation (SD)
Buffalo	0.62	0.60-0.65	0.01
Cow	0.86	0.75-0.95	0.06
Goat	0.39	0.295-0.48	0.08
Sheep	1.03	0.84-1.22	0.14

• Mean in the same columns followed by the same letter are not statistically different (P<0.05)

Table 8: Non-protein nitrogen % of milk collected from different species

Sources	TN % (Mean)	Range (%)	Standard Deviation (SD)
Buffalo	0.004	0.003-0.005	0.00057
Cow	0.004	0.003-0.005	0.00056
Goat	0.001	0.001-0.002	0.00035
Sheep	0.005	0.004-0.007	0.0093

• Mean in the same columns followed by the same letter are not statistically different (P<0.05)

Table 9: Percent Lactose contents of milk collected from different species

Sources	% Lactose (Mean)	Range (%)	Standard Deviation (SD)
Buffalo	3.92	3.28-4.8	0.003
Cow	4.03	3.0-4.6	0.045
Goat	4.66	4.0-5.5	0.033
Sheep	3.57	3.0-4.2	0.003

• Mean in the same columns followed by the same letter are not statistically different (P<0.05)

Table 10: Percent Ash contents of milk collected from different species

Sources	% Ash contents (Mean)	% Ash (Range)	Standard Deviation (SD)
Buffalo	0.40	0.38-0.44	0.01
Cow	0.36	0.29-0.48	0.06
Goat	0.28	0.20-0.39	0.64
Sheep	0.58	0.50-0.65	0.52

• Mean in the same columns followed by the same letter are not statistically different (P<0.05)

of pH, all the four species are non-significantly different from each other. As shown in Table 2 in results, the pH values of cow milk (6.65) and of buffalo milk (6.68) showed almost similar results observed by Gervilla *et al.*[18], who studied the pH of bovine milk (6.66) but value of goat (6.59) and of sheep milk (6.58) showed little variation.

Campbell and Marshall[19] found the maximum value of milk containing a higher apparent acidity is 0.23%. In the present study buffalo milk showed the lowest value (0.11%) of TTA in contrast to it the sheep milk showed the highest value (0.18%). While the value of cow (0.15%) and goat milk (0.13) falls between these two extremes.

Fat, solid non-fat and total solids: Usually the determination of fat contents is considered to be a satisfactory measure for estimating the overall quality of fresh milk but where skimming of milk as well as addition of water or dried milk powder is suspected, estimation of total solids in the representative samples may also be necessary.

Mean values and their respective range values of milk samples collected from different species of animals are given in Table 3. The representative samples collected from different species showed that the fat and total solid contents of the milk of buffalo were 5.25 and 14.04%, respectively. Similarly, samples collected from different species showed that the fat and total solid contents of the milk of cow were 4.56 and 13.73%, respectively.

Similarly, the fat and total solid contents of the milk of goat were 4.73 and 13.55% respectively and the fat and total solid contents of the milk of sheep were 8.96 and 18.53%, respectively which is quite high as compared to other samples.

The results of fat (%) showed that buffalo, cow, goat milk are non-significantly different from each other but sheep milk is significantly different from other two species. The results of SNF showed that cow and goat milk is non-significantly different from each other but sheep and buffalo milk are significantly different from all other three species. The total solids contents found by two different methods that represented almost the same results statistically as shown in Table 4. The total solids contents of different species showed non-significant with each other.

Sheep milk showed the highest value (8.96%) while the buffalo milk showed the lowest value (5.25%). The value of goat and cow milk lies in-between these two extremes. These values of cow and goat are quite similar to the finding of Hanjra *et al.*[20]. The %age fat contents of buffalo milk showed similarity with the finding of Athar and Ali[8], while sheep values find support with the results of Banda[5] and finding of Foltys[21] also support the present study. The values of total solids were discussed in results in Table 4. In that sheep milk showed the highest %age of total solid (18.53%) while the goat milk sample showed the lowest value (13.55%). Results of buffalo (14.04%) and cow milk (13.73%) ranges between the values of TS contents of the above mentioned two species. Finding of Athar and Ali[8] showed little similarity with the present study they observed that buffalo and cow milk of NARC dairy farm contained 6.5 and 16.6% and 3.8 and 12.8% fat and total solids respectively. Ibeawuchi and Dalyop[22], who studied the composition of fresh cow milk also, support the present study to little extent. The finding of Gervilla *et al.*[18] who studied the fat and total solid contents of bovine milk (7.69 and 18.17%, respectively) also supports present study.

However, the results of SNF found in this study showed significant difference (P<0.05) among the milks of buffalo (8.79%) and of goat milk (8.92%). In contrast, the SNF of milk samples obtained from cow and sheep (9.17 and 9.71%, respectively).

Total solids of milk other than fat are called "solid-non-fat" or SNF. The variations are related to seasons and lactation stage; although other reasons are less important, such as environmental conditions and breed of the animal etc[23]. The results of %age SNF were discussed in Table 5. Athar and Masud[24] and Hanjra *et al.*[20] reported similar results.

Protein contents: Quality wise animal protein especially milk protein is considered as one of the best for human

use. Protein is the next, after fat, most variant constituent of milk followed by lactose, ash, NPN and total nitrogen. In the present study, the percentages of protein varied from 1.10% (Goat milk) to 7.74% (Sheep milk). The results are based upon estimation of total nitrogen in the milk (N x 638). These results are shown in Table-6 for further discussion.

The results showed that the sheep milk had the good range (5.32-7.74%) of protein and the highest average protein contents (6.57%). However the milk of cow (5.23%) and buffalo (3.87%) were significantly different from each other and from sheep milk. The milk of goat showed the lowest protein contents (2.38%) as compare to other species. The results of four species are significantly different from each other. These results are partly supported by Louis[25], Eckles *et al.*[10] and Pien[26].

The protein value for whole milk marketed throughout the United States of America (USA) is required to be 3.5%[27].

Total nitrogen and non-protein nitrogen: Like lactose and ash contents of the milk, results of total nitrogen and non-protein nitrogen of different species are given in the Table 7 and 8 respectively. Sheep milk has highest %age total nitrogen (1.03) contents as compared to other three species and hence significantly different from them. But goat milk showed least value (0.39%) of total nitrogen, while the total nitrogen value of cow and buffalo milk ranges between these two extremes (i.e. 0.86 and 0.62, respectively). So values of all the species are significantly different to each other.

Percentage non-protein nitrogen values are shown in the Table 8. As shown in Table 8 that the sheep milk showed the highest value (0.00596) and goat milk showed the least value (0.0013) while the values of cow and buffalo milk samples were in between them and the values of these four species are significantly different to each other.

Results of %age total nitrogen (TN) were shown in Table 7 and results showed quite dissimilarity from Gervilla *et al.*[18] observation. Values of %age non-protein nitrogen (NPN) were shown in Table 9. The results of NPN were supported by the finding of Gervilla *et al.*[18] .

Lactose contents: Lactose is the principal carbohydrate of milk. Lactose contents of the milk collected from different species are given in the Table 9.

Milk samples collected from sheep showed the lowest lactose contents (3.57%) and that of goat milk showed highest value (4.66%), respectively. The lactose contents of milk collected from buffalo and cow showed 3.92 to 4.03%, respectively. The results obtained from graph showed that goat was significantly different from others and buffalo and cow milk were non-significantly different from each other.

As the results shown in Table 9, the value of %age lactose is highest in goat milk (4.654%) while lowest value was shown by sheep milk (3.568%), but the values of buffalo milk (3.918%) and of cow milk was (4.03%) that ranges between the values of above mentioned two species. These results are partly supported by the Eckles *et al.*[10] and Hanjra *et al.*[20]. The US public health service milk ordinance[6] requires the lactose contents to be around 4.8%, which is quite near to the value of the goat milk.

Ash contents: When the water of milk or any other food is removed by evaporation and the dry residue is incinerated at a low red heat, there will be left a white or nearly white ash, which contains the mineral substances. Owing the chemical changes that occur during ashing process, the ash contains carbonates, oxides and phosphates that are not present as such in the original food. The values of ash contents in different milk samples collected from different species are given in Table 10. The %age ash contents of milk samples varied from 0.40 to 0.58%, respectively.

The ash contents of sheep milk were significantly from all other different species. The ash contents of buffalo milk and cow milk were non-significantly different from each other.

Results showed that sheep milk had highest value (0.58%) while the goat milk showed the lowest value (0.28%), but the values of buffalo milk (0.40%) and cow milk (0.36%) range between the above mentioned two values. These results are partly confirmed to normal range of ash contents in milk obtained from various species[10]. All the compositional components are also supported by Kanwal *et al.*[28] who studied the composition of milk collected from venders, consumers and UHT and pasteurized milk samples.

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