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Research Article

PHYSICOCHEMICAL AND MICROBIOLOGICAL QUALITY OF MIGRATORY GOAT MILK IN THE NORTH-WESTERN HIMALAYAN REGION OF INDIA

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ABSTRACT

The present study was envisaged to assess the quality of raw milk (N=223) sampled from migratory Gaddi goats reared by nomadic pastoralists of Himachal Pradesh, a North-western state of India using standard procedures. Physical evaluation included colour and odour, immediately after sample collection. Further, the chemical analyses included fat %, solids-not-fat %, total solids %, lactose % and protein % evaluation based on the lactation stage of goat. Standard plate count, total coliform count and occurrence of *E. coli* were evaluated for assessing the microbiological quality of milk samples. All samples had an acceptable white colour and no off-odour. The chemical composition of samples revealed fat %, solids-not-fat %, total solids %, lactose % and protein % of 6.95±2.49%, 8.63±1.85%, 15.58±3.22%, 4.53±0.96% and 3.71±0.78%, respectively. A statistically significant difference was observed in the compositional quality of milk produced in different lactation stages. Out of 223, 83.86% of samples were found to have a total viable count lower than the limits established by FSSAI. The coliforms were detected in 5.8% of samples, while only 2.24% were found to be contaminated with *E. coli*. The overall results revealed good quality milk from migratory goat, indicating fairly good animal husbandry practices being adopted by nomadic pastoralists. However, there is a need to regularly educate nomadic pastoralists on clean milk production to increase their awareness on food safety.

Keywords: Goat milk, Chemical composition, Bacteriological quality, Pastoralism, Public health

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With an estimated 148.88 million population, goats are the 3rd largest milk contributing species in India (DAHD, 2019). Goat milk has an acceptable, attractive odour and taste, and consumed as an alternate of cow milk because it is known to be having several nutritional and health benefits (Stergiadis *et al.*, 2019).

As per 20th livestock census, Himachal Pradesh has goat population of 1.1 million of which 70% are reared under nomadic pastoralism (DAHD, 2019). In this region, goat husbandry forms an integral component of livestock industry and plays a vital role in the socio-economic structure of rural farmers and nomadic pastoralists. The migratory goats forage on diverse flora along their migratory tracts, leading to production of high-quality milk. Therefore, type of feed acts as a major contributory factor for deciding the quality of milk (Rohila *et al.*, 2016).

Goat milk quality is mostly linked to major physico-chemical component of fat, protein and lactose together with hygienic and clean milk production practices (Paskas *et al.*, 2020). Good quality raw goat milk must be devoid of off-flavours and objectionable colour and odour, high in chemical composition, low in bacterial count, and free of pathogenic microorganisms. Therefore, it becomes imperative to monitor the physicochemical and bacteriological quality of Goat milk in order to safeguard human health.

Although, numerous studies have been conducted on quality evaluation of bovine milk in India (Kumar *et al.*, 2022; Pandey *et al.*, 2021) but very few have been conducted on goat milk (Argade *et al.*, 2022). Keeping in view the aforementioned facts, the present study was conducted with the objective to assess physico-chemical and bacteriological quality of milk obtained from migratory Gaddi goats reared by nomadic pastoralists of Himachal Pradesh.

MATERIALS AND METHODS

A total of 223 raw milk samples were collected by full hand-milking from lactating migratory Gaddi goats reared under extensive system by observing all aseptic precautions. Approximately 50 mL of milk was drawn into sterile containers. Based on number of days in milk (DIM), samples were divided into 3 stages *viz.* 1st (DIM < 80 days), 2nd (DIM 80-140 days) and 3rd stage (DIM >140 days). The samples were labelled and transported to laboratory under ice cold conditions and stored in dark at -20° C till further analysis. The physical parameters *viz*. colour and odour of the individual milk sample were immediately recorded after collection of samples in sterile containers at collection site.

Further, for chemical analyses, milk samples were analysed in ultrasonic milk analyser (EKOMILK TOTALTM) within 24 hours of collection. The parameters analysed were fat %, SNF (Solids not fat) %, TS (Total solids) %, lactose %, protein % and water %. The samples

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were thawed to room temperature before analysis. Repeated washings were given to milk analyzer after every sample to avoid false positive or false negative results.

Then all the collected samples were evaluated for their bacteriological quality based on Standard plate count (SPC), Total coliform count (TCC) and occurrence of *E. coli* using standard bacteriological procedures prescribed in IS: 1479, Part III (1962). For SPC and TCC, samples were diluted with normal saline solution using 10-fold serial dilution method. Then, 1 mL of diluted aliquot from appropriate dilution tube was mixed with Plate count agar (PCA) for SPC and with Violet Red Bile Agar (VRBA) for TCC using pour plate method in duplicate. The plates were then incubated for 24-48 hours at 37° C and the results were expressed as:

SPC or TCC (CFU/mL) = No. of colonies forming unit × dilution factor

The results obtained were then compared with limits established by FSSAI (FSSAI, 2015). The samples positive for TCC were further investigated for presence of *E. coli*. A single coliform colony was inoculated into tryptone water and incubated for 24-48 hours at 44 °C. Formation of red colour on addition of KOVAC's reagent provisionally indicated presence of *E. coli*. Therefore, KOVAC's positive samples were then further subjected to detailed biochemical profiling of isolate for confirmation as *E. coli* (ICMR, 2019).

The data obtained from physico-chemical analyses was presented in tables and graphs using excel spread sheets. All the analyses were performed using IBM® SPSS® statistical package (SPSS Inc., Chicago, IL), version 22.0 for windows and results were expressed as mean± standard deviation. The univariate analysis of variance (ANOVA) followed by Tukey's post hoc test was used to evaluate significance of difference ($p < 0.05$) between results.

RESULTS AND DISCUSSIONS

Physicochemical parameters

All the samples exhibited acceptable colour and odour. The colour of milk was whitish without any off-odour indicating suitability for further analyses. The results of chemical analyses have been presented in Table 1.

Based on stage of lactation in goats, the samples were divided into 3 stages *viz*. 1st, 2nd and 3rd stage with 162, 50 and 11 number of samples, respectively (Table 1). The mean fat % was found to be 7.38±2.62%, 5.68±1.78% and 6.45±0.53% in 1st, 2nd and 3rd stage of lactation, respectively, with overall mean of 6.95±2.49%. Statistically significant difference ($p < 0.05$) was observed in mean fat % of milk drawn during 1st and 2nd stage of lactation. The present results are comparable with the findings of Mal *et al.* (2018), wherein the authors have reported fat % to be highest during 1st stage of lactation. High fat content during 1st stage of lactation can be attributed to mobilization of fatty acids from body fat reserves to the mammary glands during negative energy balance (Curro *et al.*, 2019). However, a relatively higher overall fat % of 6.95± 2.49% have been observed in present study than that reported earlier (Mal *et al.*, 2018). In a similar study conducted by Jaafar *et al.* (2018), fat content was reported to be as high as 7.36%.

The mean SNF content during 1st, 2nd and 3rd stage of lactation was found to be 8.67± 1.83%, 8.82±2.03% and 9.33±0.65%, respectively without any statistically significant difference ($p > 0.05$). The overall SNF content was 8.63±1.85%. Similar results have also been reported by Isidro-Requejo *et al.* (2019) in which SNF content was found to be 8.9±0.13%. Ravula and Ramachandra (2016) also reported SNF content of 9.18±0.30% in goat milk.

During 1st, 2nd and 3rd stage of lactation, the mean TS content was 16.05±3.09%, 14.01±3.51% and 15.78±0.72%, respectively with overall mean of 15.58±3.22%. On statistical analysis, significant difference was found between 1st and 2nd stage of lactation ($p < 0.05$) but difference was non-significant between 1st and 3rd stage; 2nd and 3rd stage. Statistical significance difference between 1st and 2nd stage can be attributed to difference in fat content of milk. Similar findings were reported by Mayer and Fiechter (2012), wherein TS content of 15.78% was observed in goat milk. Mal *et al.* (2018) also reported higher TS content of 15.86% in Gaddi goat milk.

Lactose content was also found to remain uninfluenced by the lactation stage. The mean lactose % was found to be 4.53±0.94%, 4.36±1.07% and 5.27±0.20% during 1st, 2nd and 3rd stage of lactation, respectively with overall mean being 4.53±0.96%. The difference in lactose content in different stages of lactation was statistically insignificant ($p > 0.05$). Bhosale *et al.* (2009) also reported that lactose content was not affected by the stage of lactation. Singh *et al.* (2014) reported similar results with lactose content of 4.43±0.01%.

The mean protein content found during 1st, 2nd and 3rd lactation stage were 3.74±0.73%, 3.56±0.97% and 3.90± 0.35%, respectively. The protein content also remained unaffected by the lactation stage ($p > 0.05$) with overall mean of 3.71±0.78% which is comparable with the findings of Mahmood and Usman (2010). Getaneh *et al.*

Table 1. Chemical composition of raw migratory goat milk during various stages of lactation

Lactation stage	No. of samples	Fat %	SNF %	TS %	Lactose %	Protein %
1	162	7.38 ± 2.62^{a}	8.67 ± 1.83^{a}	16.05 ± 3.09^{a}	4.53 ± 0.94^{a}	3.74 ± 0.73^{a}
2	50	5.68 ± 1.78^{b}	8.82 ± 2.03^{a}	14.01 ± 3.51^{b}	4.36 ± 1.07^{a}	3.56 ± 0.97^{a}
3	11	6.45 ± 0.53^{ab}	9.33 ± 0.65^{a}	15.78 ± 0.72^{ab}	5.27 ± 0.20^{a}	3.90 ± 0.35^{a}
Overall Mean	223	6.95 ± 2.49	8.63 ± 1.85	15.58 ± 3.22	4.53 ± 0.96	3.71 ± 0.784

Different superscripts in a column denote significant difference [($p < 0.05$), Tukey's post hoc test]

Table 2. Bacteriological quality of raw goat milk samples

Quality parameter	No. of Samples analysed	Samples exceeding FSSAI limits (%)	Established limits
Standard Plate Count	223	36 (16.14 %)	2×10^{5} CFU/mL
Total coliform Count	223	13 (5.8 %)	10 cfu/mL
E. coli	13*	05 (2.24 %)	Absent in 0.1mL

*Samples found positive for coliform count were tested for presence of *E. coli*

(2016) also reported that goat milk contained higher protein content as compared to traditional cow milk. Alyaqoubi *et al.* (2015) similarly reported high protein % in Jamnapari goats with mean value of 5.11%.

Bacteriological quality

Out of 223 raw migratory goat milk samples analysed, 36 (16.14%) and 13 (5.8%) samples were found to be exceeding limits for SPC and TCC, respectively (Table 2). Out of 13 coliform positive samples, 5 were found to be contaminated with *E. coli* based on cultural, morphological and biochemical characterization. SPC and TCC signify the microbiological requirements of milk with respect to hygiene indicator organisms. Therefore, contamination of 16.14% of samples with aerobic plate count exceeding FSSAI limits and 13 (5.8%) samples exceeding limits of total coliform count can be attributed to poor knowledge of nomadic pastoralists on animal hygiene and clean milk production.

The *E. coli* could be isolated from only 5 (2.24%) goat milk samples. The studies on physicochemical and bacteriological quality of goat milk are very meagre. However, high incidence of *E. coli* has been found in bovine milk (Kumar *et al.*, 2013). Contamination of milk and milk products, with pathogenic bacteria is largely due to processing, handling and unhygienic conditions. In the study conducted by Soomro *et al.* (2002) the prevalence of *E. coli* in milk was 52%. Similarly, prevalence of *E. coli* in 26% of the milk samples (Farzan et al., 2012) and 31.6% samples (Nanu *et al.*, 2007) has also been reported earlier. However, in the present investigation, detection of *E. coli* in only 2.24% of analysed samples reflects the good health status of migratory goats being reared by shepherds of North-western Himalayan region of India.

CONCLUSIONS

Owing to easy digestibility and proximity to human milk, goat milk has gained significant reputation in human health. Considering the nutritional value and health benefits of goat milk, its demand for domestic consumption and export is expected to rise in coming years. In current study, all the samples exhibited good physicochemical and bacteriological properties. Therefore, it can be concluded that traditional migratory system has not yet impacted the quality of milk to that extent and if properly processed such milk can prove to be an excellent source of nutrients without any health risk to consumers. However, the obtained results further necessitates the need for continual education of nomadic pastoralist engaged in goat farming practices on clean and hygienic milk production to make migratory goat rearing a sustainable system with the potential for export of quality goat milk.

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RETRACTION OF ARTICLE

This article earlier available at https://www.luvas.edu.in/haryana-veterinarian/download/harvet2016-dec/1.pdf entitled *"Occurrence of some organochlorine pesticide residues in poultry feed and meat"* has been retracted by the authors because of some error made during the data analysis process of the experimental observations due to counting the number of samples showing the concentration of pesticide below its corresponding Limit of Detection. All authors take full responsibility for this mistake and sincerely apologize for any inconvenience it may cause.

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