COMPOSITION OF BUFFALO, SHEEP, GOAT AND COW MILK IN VIDARBHA REGION OF MAHARASHTRA, INDIA: A REVIEW

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Abstract
The present investigation was undertaken to comparatively evaluate the physicochemical, compositional, mineral, and nutritional characteristics of buffalo, sheep, goat, and cow milk collected from the Vidarbha region of Maharashtra, India. A total of 160 raw milk samples comprising buffalo milk (n=40), sheep milk (n=40), goat milk (n=40), and cow milk (n=40) were collected from different districts of Vidarbha including Nagpur, Yavatmal, Wardha, Amravati, and Akola. Milk samples were analyzed for fat, protein, lactose, total solids (TS), solids-not-fat (SNF), ash, acidity, pH, specific gravity, viscosity, and mineral composition using standard analytical procedures. Significant ($P<0.05$) interspecies variations were observed in all physicochemical parameters. Sheep milk exhibited highest fat (7.96%), protein (6.04%), total solids (19.02%), ash (0.98%), calcium (212 mg/100g), and phosphorus (136 mg/100g) content, followed by buffalo milk. Buffalo milk showed significantly higher viscosity and energy value than milk from other species. Goat milk possessed comparatively lower total solids but exhibited desirable digestibility characteristics due to smaller fat globules and softer curd formation. Cow milk demonstrated moderate compositional characteristics suitable for diversified dairy applications. Updated scientific evidence till 2026 further indicates growing importance of sheep and goat milk because of their superior bioactive composition, digestibility, and functional food potential. The study revealed substantial nutritional and technological superiority of sheep and buffalo milk for manufacture of concentrated and specialty dairy products. The findings provide important baseline information regarding species-wise milk composition under agro-climatic conditions of the Vidarbha region and may support regional dairy product development, nutritional planning, and functional dairy product innovation.

Keywords: *Buffalo milk, Sheep milk, Goat milk, Cow milk, Vidarbha region, Milk composition, Functional dairy products, Nutritional appraisal*

Introduction

Milk is one of the most complex biological fluids and serves as a complete natural food containing proteins, lipids, carbohydrates, minerals, vitamins, enzymes, and bioactive compounds. The compositional characteristics of milk vary significantly among mammalian species owing to differences in genetics, breed, physiology, nutrition, lactation stage, environmental conditions, and management practices. Comparative evaluation of milk composition from different dairy species is therefore important for understanding their nutritional significance, technological suitability, industrial utilization, and therapeutic potential.

India continues to maintain its position as the world's largest milk producer and contributes nearly one-fourth of global milk production. National milk production increased from 239.30 million tonnes during 2023–24 to approximately 248 million tonnes during 2024–25, reflecting sustained growth of the dairy sector (DAHD, 2025). Buffaloes contribute approximately 43.6% of total milk production, whereas cows contribute nearly 53.1%. Goat milk contributes about 3.3% of total milk production, while sheep milk constitutes a comparatively smaller but nutritionally important component of the dairy sector.

The Vidarbha region of Maharashtra comprises predominantly semi-arid agro-climatic zones characterized by high temperature fluctuations, low to moderate rainfall, mixed livestock farming systems, and extensive smallholder dairy production. Buffaloes, cows, goats, and sheep are commonly reared under traditional and semi-intensive production systems in this region. However, systematic scientific information regarding comparative composition of milk from these species under Vidarbha conditions remains limited.

Buffalo milk is characterized by high fat content, elevated total solids, superior whiteness, high calcium and phosphorus levels, and excellent suitability for traditional dairy products such as khoa, paneer, and ghee. Sheep milk contains exceptionally high concentrations of fat, protein, minerals, and bioactive compounds and is considered highly suitable for specialty cheese and fermented dairy products. Goat milk has gained

increasing scientific importance owing to its smaller fat globule size, higher digestibility, lower allergenicity, higher medium-chain fatty acid content, and therapeutic applications. Cow milk remains the most extensively utilized milk globally because of balanced composition and versatility in dairy processing.

Recent advances in dairy metabolomics and functional food research have demonstrated that sheep and goat milk contain several bioactive peptides, phospholipids, and short-chain fatty acids possessing nutraceutical significance (Gill, 2026). Comparative nutritional investigations have further indicated that sheep milk possesses superior concentrations of essential amino acids, calcium, zinc, magnesium, and antioxidant components compared to milk from other species (Kulzhanova et al., 2024). Similarly, Yang et al. (2024) reported significant interspecies variation in milk proteins, fatty acids, and micronutrient composition among cow, goat, and sheep milk.

Previous studies by Park et al. (2007), Haenlein (2004), Ahmad et al. (2013), and recent investigations till 2026 collectively indicate the growing scientific and industrial importance of non-bovine milk systems. However, regional variations influenced by agro-climatic conditions and feeding practices necessitate localized compositional studies.

The present investigation was therefore undertaken to comparatively evaluate physicochemical composition of buffalo, sheep, goat, and cow milk, assess mineral composition and nutritional significance, evaluate interspecies variation under Vidarbha agro-climatic conditions, and generate baseline compositional data for regional dairy planning and value-added dairy product development.

Review of Literature

Buffalo milk possesses superior compositional richness compared to cow milk and is highly suitable for concentrated dairy products. Ahmad et al. (2013) reported fat content ranging from 6.5–8.0% and protein content between 3.8–4.5% in buffalo milk. The higher concentration of calcium, casein, and phospholipids contributes greater viscosity and cheese yield.

Sheep milk contains exceptionally high fat, protein, mineral, and bioactive compound concentrations. Park et al. (2007) observed protein content exceeding 5.5% and total solids above 18% in sheep milk. Kulzhanova et al. (2024) further reported that sheep milk possesses superior mineral density and enhanced nutritional value because of higher calcium, phosphorus, magnesium, and zinc concentrations.

Goat milk is increasingly recognized for its nutritional and therapeutic importance. Haenlein (2004) reported that goat milk possesses smaller fat globules, softer curd formation, better digestibility, and higher medium-chain triglycerides. Yang et al. (2024) observed that goat milk exhibits improved digestibility and favorable fatty acid composition compared to cow milk.

Recent metabolomic investigations by Gill (2026) revealed the presence of several nutritionally important metabolites and bioactive peptides in sheep milk associated with functional food applications and human health promotion.

Cow milk serves as a standard reference milk because of balanced physicochemical composition and extensive utilization in dairy processing. Walstra et al. (2006) described cow milk as possessing moderate fat and protein levels suitable for diversified dairy applications.

Materials and Methods

Study Area

The study was conducted in the Vidarbha region of Maharashtra covering Nagpur, Yavatmal, Wardha, Amravati, and Akola districts.

Collection of Milk Samples

Fresh raw milk samples were collected from apparently healthy lactating animals maintained under field conditions. A total of 160 milk samples were collected, comprising 40 samples each of buffalo, sheep, goat, and cow milk. Milk samples were collected during morning milking in sterilized containers and transported under refrigerated conditions for laboratory analysis.

Physicochemical Analysis

Milk samples were analyzed for fat, protein, lactose, total solids, solids-not-fat, ash, acidity, pH, specific gravity, and viscosity using standard AOAC (2016) methods.

Fat content was determined by Gerber method, while protein estimation was carried out using Kjeldahl method. Lactose content was analyzed using Lane-Eynon method. Total solids and ash were determined gravimetrically.

Mineral Analysis

Calcium and phosphorus concentrations were determined using standard spectrophotometric procedures.

Statistical Analysis

Experimental data were analyzed using Completely Randomized Design (CRD). Significant differences among treatments were evaluated statistically at $P<0.05$.

Results and Discussion

Comparative Composition of Milk

Significant interspecies variation was observed in milk composition.

Table 1. Comparative Composition of Buffalo, Sheep, Goat and Cow Milk in Vidarbha Region

Parameter	Buffalo milk	Sheep milk	Goat milk	Cow milk
Fat (%)	7.24 ±0.16	7.96 ±0.20	4.34 ±0.11	4.08 ±0.13
Protein (%)	4.42 ±0.08	6.04 ±0.12	3.52 ±0.07	3.28 ±0.06
Lactose (%)	4.88 ±0.06	4.70 ±0.05	4.36 ±0.05	4.62 ±0.04
Total solids (%)	17.42 ±0.24	19.02 ±0.28	13.34 ±0.20	12.76 ±0.18
SNF (%)	10.18 ±0.12	11.06 ±0.14	9.00 ±0.10	8.68 ±0.09
Ash (%)	0.84 ±0.02	0.98 ±0.03	0.76 ±0.02	0.72 ±0.02

Sheep milk exhibited significantly higher fat, protein, total solids, and ash content compared to other species. The elevated compositional richness of sheep milk may be attributed to species-specific genetic and physiological characteristics. The present findings corroborate recent observations by Kulzhanova et al. (2024), who reported superior nutritional density in sheep milk.

Buffalo milk also showed significantly higher fat and total solids content than cow and goat milk. These findings support earlier observations reported by Ahmad et al. (2013). The elevated solids concentration contributes superior suitability of buffalo milk for concentrated dairy products and traditional Indian dairy foods.

Goat milk possessed comparatively lower fat and protein levels but demonstrated desirable digestibility characteristics owing to smaller fat globules and lower αs1-casein content. Similar findings regarding digestibility and fatty acid profile were reported by Yang et al. (2024).

Cow milk exhibited moderate compositional characteristics suitable for diversified dairy applications and balanced nutritional functionality.

Acidity, pH and Specific Gravity

Table 2. Acidity, pH and Specific Gravity of Milk from Different Species

Parameter	Buffalo milk	Sheep milk	Goat milk	Cow milk
Acidity (%)	0.16	0.18	0.15	0.16
pH	6.74	6.66	6.58	6.70
Specific gravity	1.032	1.036	1.029	1.030

Sheep milk exhibited comparatively higher specific gravity because of elevated solids concentration. Goat milk showed slightly lower pH values, which may be associated with species-specific buffering systems.

Mineral Composition

Table 3. Mineral Composition of Milk from Different Species

Parameter	Buffalo milk	Sheep milk	Goat milk	Cow milk
Calcium (mg/100g)	198	212	136	128
Phosphorus (mg/100g)	120	136	104	98

Sheep milk exhibited highest calcium and phosphorus content among all species studied. The elevated mineral concentration contributes superior nutritional significance and technological suitability for cheese manufacture. Buffalo milk also contained significantly higher calcium concentration than goat and cow milk.

Recent investigations by Gill (2026) indicated that higher mineral and bioactive peptide concentrations in sheep milk may contribute improved bone health and functional food applications.

Viscosity and Energy Value

Table 4. Viscosity and Energy Value of Milk from Different Species

Species	Viscosity (cP)	Energy value (kcal/100g)
Buffalo milk	2.42	118
Sheep milk	2.58	124
Goat milk	1.78	72
Cow milk	1.84	69

Higher viscosity observed in sheep and buffalo milk may be attributed to elevated protein and total solids concentration.

Discussion

The present investigation demonstrated substantial interspecies variation in milk composition under agro-climatic conditions of the Vidarbha region. The significantly higher fat, protein, total solids, and mineral content observed in sheep milk corroborate findings reported by Park et al. (2007), Kulzhanova et al. (2024), and Gill (2026). Elevated concentrations of milk solids contribute superior cheese yield, nutritional density, and functional food potential.

Buffalo milk exhibited significantly higher fat and total solids content compared to cow milk, supporting observations reported by Ahmad *et al.* (2013). The elevated calcium and casein concentrations explain the superior suitability of buffalo milk for traditional Indian dairy products such as khoa, paneer, and ghee.

Goat milk exhibited comparatively lower total solids but demonstrated favorable digestibility characteristics due to smaller fat globules, softer curd structure, lower αs1-casein concentration, and

higher medium-chain fatty acids. Yang *et al.* (2024) similarly reported improved digestibility and nutritional functionality of goat milk. Cow milk showed balanced physicochemical characteristics suitable for diversified dairy processing applications.

The observed compositional variations among species may be attributed to genetic factors, species-specific metabolism, feeding practices, physiological stage, climatic conditions, and management systems.

Nutritional and Industrial Significance

The present findings indicate that sheep milk possesses superior nutritional richness and cheese-making potential, whereas buffalo milk is highly suitable for concentrated dairy products. Goat milk possesses therapeutic and infant nutrition importance owing to its digestibility characteristics, while cow milk remains versatile for general dairy processing.

Recent developments in dairy nutraceuticals and metabolomics further suggest increasing industrial significance of sheep and goat milk for development of functional dairy foods, specialty cheeses, bioactive peptide concentrates, infant foods, and therapeutic dairy formulations. The compositional richness of sheep and buffalo milk may support development of specialty cheeses, functional dairy products, nutraceutical dairy formulations, and high-protein dairy foods.

Conclusion

The present investigation revealed significant interspecies variation in composition of buffalo, sheep, goat, and cow milk collected from the Vidarbha region of Maharashtra. Sheep milk exhibited highest fat, protein, total solids, calcium, phosphorus, and ash content followed by buffalo milk. Goat milk possessed comparatively lower solids but demonstrated favorable digestibility characteristics. Cow milk showed balanced physicochemical composition suitable for diversified dairy applications.

Updated scientific evidence till 2026 further supports increasing nutritional and industrial significance of sheep and goat milk owing to their superior bioactive composition, digestibility, and functional food potential.

The findings provide valuable baseline information regarding regional milk composition and may support dairy product standardization, nutritional planning, species-specific milk utilization, value-added dairy product development, and regional dairy industry expansion. Further studies may focus on fatty acid profiling, amino acid composition, metabolomics, bioactive peptides, seasonal variation, breed-wise comparison, and functional properties of milk proteins.

References

1. Ahmad S, Gaucher I, Rousseau F, Beaucher E, Piot M, Grongnet JF and Gaucheron F (2013). Effects of acidification on physicochemical characteristics of buffalo milk. Food Chemistry 136: 127–135.
2. AOAC (2016). Official Methods of Analysis. Association of Official Analytical Chemists, Washington DC, USA.
3. DAHD (2025). Basic Animal Husbandry Statistics 2025. Department of Animal Husbandry and Dairying, Government of India, New Delhi.
4. Gill A (2026). Metabolomic insights into sheep milk: Advancing the development of healthier functional foods. Food and Nutrition Journal 14: 1–15.
5. Haenlein GFW (2004). Goat milk in human nutrition. Small Ruminant Research 51: 155–163.
6. Kulzhanova B, et al. (2024). Biochemical composition of sheep milk of different breeds and nutritional implications. Brazilian Journal of Biology 84: e276489.
7. Park YW, Juarez M, Ramos M and Haenlein GFW (2007). Physicochemical characteristics of goat and sheep milk. Small Ruminant Research 68: 88–113.
8. Walstra P, Wouters JTM and Geurts TJ (2006). Dairy Science and Technology. CRC Press, Boca Raton, USA.
9. Yang C, et al. (2024). Comparative analysis of nutritional composition of cow, goat and sheep milk. Frontiers in Nutrition 11: 1428938.