Volume 4, Issue 9
September I 2026

Agri Roots
e- Magazine

www.agrirootsmagazine.in

ISSN: 2583-9071

Colostrum to Mature Milk: Mineral and Vitamin Dynamics Across Buffalo Breeds — A Review

ARTICLE ID: 0413

Vishal Yadav[1], Ruchi Yadav[2]

[1,2] Ph.D. Scholars, Department of Animal Husbandry and Dairying (AHD), Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Buffalo (*Bubalus bubalis*) colostrum undergoes rapid and measurable biochemical changes during the first two weeks after calving, with the most pronounced shifts occurring within the first 48–120 hours postpartum. This review compiles quantitative data from peer-reviewed studies on Egyptian, Murrah, Kundi, Nili-Ravi, Jaffarabadi, Surti, and Mediterranean buffaloes to document changes in macro-minerals (Ca, Mg, Na, K, and P), micro-minerals (Fe, Cu, Zn, and Pb), fat-soluble vitamins (A and E), and key bioactive components, including immunoglobulins, insulin-like growth factor-1 (IGF-1), and lactoferrin, from calving through the transition to mature milk. Breed-wise numerical comparisons are presented to highlight genetic variation superimposed on the universal effect of lactation stage. The compiled data provide specific reference values that may be useful to students, dairy technologists, veterinarians, and researchers requiring quantitative information on buffalo colostrum composition rather than qualitative descriptions of general trends alone.

Colostrum represents the first mammary secretion produced after parturition and is compositionally distinct from mature milk. In buffaloes, the transition from colostrum to mature milk is rapid and measurable within hours after calving. Several macro- and micro-elements decline substantially during the first few days postpartum, whereas lactose and other components generally change in the opposite direction.

This review synthesizes quantitative information reported in peer-reviewed studies on Egyptian buffaloes (Abd El-Fattah et al., 2012), Murrah buffaloes (Dang et al., 2009), Kundi and Nili-Ravi buffaloes (Ahmad et al., 2024), and comparative buffalo-breed studies involving Murrah, Nili-Ravi, Jaffarabadi, and Mediterranean buffaloes. Particular emphasis is placed on numerical changes in minerals, vitamins, immunoglobulins, and other bioactive components during the transition from colostrum to mature milk.

The objective is to provide a consolidated quantitative reference that illustrates both the universal changes associated with lactation stage and the breed-specific differences reported among buffalo populations.

Macro-Mineral Changes: Calcium, Magnesium, Sodium, Potassium and Phosphorus

The following table presents mean concentrations of selected macro-minerals reported in Egyptian buffalo colostrum from the time of calving through Day 14, when the composition approaches that of mature milk.

Table 1. Changes in macro-mineral concentration in Egyptian buffalo colostrum during the transition to mature milk

Time postpartum	Ca (mg/100 g)	Mg (mg/100 g)	Na (mg/100 g)	K (mg/100 g)	P (mg/100 g)
At calving (0 h)	279.60	35.52	150.50	107.00	58.00
6 h	273.20	33.34	128.80	105.30	56.00
12 h	270.60	29.60	105.80	101.30	54.00
24 h (Day 1)	261.80	29.20	81.90	102.20	53.00
48 h (Day 2)	239.80	25.10	76.56	100.10	52.00
72 h (Day 3)	190.90	24.12	56.04	89.20	52.00
96 h (Day 4)	160.10	19.90	63.28	82.63	54.00
120 h (Day 5)	140.20	17.50	36.44	79.80	52.00
Day 14 (mature)	114.00	13.46	38.20	74.00	57.00

Source: *Abd El-Fattah et al. (2012),* BMC Veterinary Research*, 8:19. Values are means (mg/100 g).*

Calcium decreased from 279.60 mg/100 g at calving to 114.00 mg/100 g by Day 14, representing a decline of approximately 59%. Magnesium decreased from 35.52 to 13.46 mg/100 g, corresponding to approximately a 62% decline. Sodium showed the steepest decline among the macro-minerals, decreasing from 150.50 to 38.20 mg/100 g, equivalent to approximately a 75% reduction over the two-week period.

Potassium declined more gradually, from 107.00 to 74.00 mg/100 g. In contrast, phosphorus remained comparatively stable, changing from 58.00 to 57.00 mg/100 g during the same period. Thus, phosphorus was the most stable macro-mineral in this dataset.

Micro-Mineral Changes: Iron, Copper, Zinc and Lead

Micro-minerals also exhibited substantial changes during the transition from colostrum to mature milk, with iron and copper showing particularly pronounced reductions.

Table 2. Changes in micro-mineral concentration in Egyptian buffalo colostrum

Time postpartum	Fe (mg/100 g)	Cu (mg/100 g)	Zn (mg/100 g)	Pb (mg/100 g)
At calving (0 h)	2.36	0.186	0.23	0.028
6 h	1.50	0.118	0.21	0.024
12 h	0.77	0.084	0.21	0.020
24 h	0.76	0.082	0.20	0.018
48 h	0.66	0.077	0.17	0.018
72 h	0.60	0.060	0.15	0.012
96 h	0.51	0.060	0.13	0.010
120 h (Day 5)	0.54	0.052	0.12	0.010
Day 14 (mature)	0.53	0.020	0.16	0.009

Source: *Abd El-Fattah et al. (2012),* BMC Veterinary Research*, 8:19. Values are means (mg/100 g).*

Iron concentration decreased from 2.36 mg/100 g at calving to 0.53 mg/100 g by Day 14, representing an approximate 78% decline. Most of this reduction occurred within the first 12 hours, when iron decreased from 2.36 to 0.77 mg/100 g.

Copper showed an even greater reduction, decreasing from 0.186 to 0.020 mg/100 g, corresponding to an approximate 89% reduction. In this dataset, copper therefore exhibited the most pronounced decline among the measured trace minerals.

Zinc decreased more moderately, from 0.23 mg/100 g at calving to 0.16 mg/100 g by Day 14. Lead decreased from 0.028 to 0.009 mg/100 g over the same period.

Vitamin A and Vitamin E Dynamics

Unlike several minerals, vitamin concentrations in buffalo colostrum did not demonstrate a simple linear decline. Both vitamin A and vitamin E exhibited fluctuations during the early postpartum period before approaching levels associated with mature milk.

Table 3. Changes in vitamin A and vitamin E concentrations in Egyptian buffalo colostrum

Time postpartum	Vitamin A (IU/100 ml)	Vitamin E (IU/100 ml)
At calving (0 h)	166.67	342.00
6 h	125.00	402.00

12 h	145.83	336.00
24 h	188.03	396.00
48 h	171.90	387.00
72 h	156.25	378.00
96 h	146.20	352.97
120 h (Day 5)	138.20	341.67
Day 14 (mature)	136.70	330.00

Source: *Abd El-Fattah et al. (2012),* BMC Veterinary Research*, 8:19. Values are expressed as IU/100 ml.*

Vitamin E reached a maximum concentration of 402.00 IU/100 ml at 6 hours postpartum, compared with 342.00 IU/100 ml at calving, before gradually decreasing to 330.00 IU/100 ml by Day 14. Relative to the initial calving value, this represents an overall decline of approximately 3.5%, making vitamin E the more stable of the two fat-soluble vitamins evaluated.

Vitamin A followed a less consistent pattern. Its concentration decreased from 166.67 IU/100 ml at calving to 125.00 IU/100 ml at 6 hours, subsequently increased to 188.03 IU/100 ml at 24 hours, and then gradually decreased to 136.70 IU/100 ml by Day 14. This represents a net decline of approximately 18% relative to the initial calving value.

The same study reported that buffalo colostrum contained approximately 1.5 times less vitamin A than cow colostrum at calving, whereas vitamin E concentrations in buffalo colostrum remained consistently higher than those in cow colostrum throughout the study period.

Bioactive Components: Immunoglobulins, IGF-1 and Lactoferrin

In addition to minerals and vitamins, colostrum contains high concentrations of biologically active components that contribute to neonatal protection, development, and immune function. These include immunoglobulins, insulin-like growth factor-1 (IGF-1), and lactoferrin.

Table 4. Changes in selected bioactive components of Egyptian buffalo colostrum

Time postpartum	**IgG (mg/ml)**	**IgM (mg/ml)**	**IGF-1 (ng/ml)**	**Lactoferrin (mg/ml)**
At calving (0 h)	33.20	3.00	801.90	1.085
Day 5 (120 h)	~2% of initial	Declined sharply	~181 (77.4% decrease)	Declined sharply
Day 14 (mature)	Near-baseline	Near-baseline	Near-baseline	0.123

Source: *Abd El-Fattah et al. (2012),* BMC Veterinary Research*, 8:19.*

IgG and IgM decreased by approximately 97.9% and 97.5%, respectively, within the first five days postpartum. IGF-1 decreased from 801.90 ng/ml at calving to approximately 181 ng/ml by Day 5, representing a 77.44% reduction. Lactoferrin also declined substantially, from 1.085 mg/ml at calving to 0.123 mg/ml by Day 14.

Immunoglobulin Changes in Murrah Buffaloes

Dang et al. (2009) investigated changes in colostrum composition in Murrah buffaloes following calving. The study reported an average IgG concentration of 54.0 mg/ml at calving, together with IgA at 3.22 mg/ml and IgM at 5.22 mg/ml on Day 1. These immunoglobulin concentrations were reported to be higher than corresponding values in cows.

Somatic cell count (SCC) was elevated at calving, reaching approximately 500,000 cells/ml, and decreased to 180,000 cells/ml by Day 5. Phagocytic activity was reported to peak on Day 1, further emphasizing the biological importance of early colostrum intake.

Table 5. Changes in immunoglobulins and somatic cell count in Murrah buffalo colostrum

Day after calving	IgG (mg/ml)	IgA (mg/ml)	IgM (mg/ml)	SCC (per ml)
Day 1	54.0 (average at calving)	3.22	5.22	500,000
Day 2	Declining	Declining	Declining	Reduced significantly
Day 5	Significantly lower	Lower	Lower	180,000

Source: *Dang et al. (2009),* Tropical Animal Health and Production, *41(7):1213–1217.*

The rapid decline in immunoglobulins after calving reinforces the importance of timely colostrum administration to newborn buffalo calves.

Breed-Wise Numerical Comparison

Buffalo breeds differ in their milk-production characteristics and in the concentration of individual milk components. The available literature demonstrates that breed effects may occur alongside the strong effect of lactation stage.

Kundi versus Nili-Ravi Buffalo Colostrum at 6 Hours Post-Calving

Ahmad et al. (2024) compared the physicochemical and antimicrobial characteristics of colostrum and milk from Kundi and Nili-Ravi buffaloes at different stages following calving. At 6 hours postpartum, clear differences were observed between the two breeds.

Table 6. Physicochemical characteristics of Kundi and Nili-Ravi buffalo colostrum at 6 hours postpartum

Parameter	Kundi Buffalo	Nili-Ravi Buffalo
Fat (%)	8.40 ± 0.06	6.00 ± 0.06
Protein (%)	13.82 ± 0.33	12.34 ± 0.72
Lactose (%)	2.72 ± 0.14	2.25 ± 0.01
SNF (%)	20.07 ± 0.01	19.79 ± 0.01
Total solids (%)	28.91 ± 0.01	25.98 ± 0.01
Ash (%)	1.04 ± 0.10	0.98 ± 0.04
pH	6.07 ± 0.00	6.37 ± 0.01
Viscosity	6.98 ± 0.01	7.33 ± 0.01

Source: Ahmad et al. (2024), *Journal of Population Therapeutics and Clinical Pharmacology*, 31(1):1264–1276.

Kundi buffalo colostrum contained higher fat (8.40% vs. 6.00%), protein (13.82% vs. 12.34%), and total solids (28.91% vs. 25.98%) than Nili-Ravi colostrum at the same 6-hour postpartum time point. In contrast, Nili-Ravi colostrum exhibited marginally higher viscosity and pH. These findings indicate the presence of breed-specific physicochemical signatures even within a relatively narrow postpartum period.

Murrah, Nili-Ravi, Jaffarabadi, Surti and Mediterranean Buffaloes: Mature Milk Characteristics

Data from comparative breed studies provide further evidence of variation in mature milk composition among buffalo breeds.

Table 7. Comparative mature milk characteristics among selected buffalo breeds

Breed	Fat (%)	Protein (%)	SNF (%)	Distinctive feature
Murrah	8.02 (reported maximum among breeds compared)	Higher than Nili-Ravi	9.41 (highest reported)	Highest whey protein and unsaturated fatty acids
Nili-Ravi	Lower than Murrah	Lower than Murrah	Lower than Murrah	Highest saturated fatty acids and casein fractions
Mediterranean (Italy)	Highest among Murrah, Nili-Ravi and Mediterranean trial	Highest among the three	Not separately reported	Highest cholesterol, sphingomyelin and lanosterol

***Sources:** Zhou et al. (2018); Abdel-Hamid et al. (2023).*

A comparative study conducted in China on Murrah and Nili-Ravi buffalo milk reported significantly higher protein and total solids in Murrah buffalo milk than in Nili-Ravi milk. Across all buffalo samples, the average protein, fat, lactose, and total solids contents were 4.76%, 7.31%, 5.19%, and 18.40%, respectively. Amino acid analysis in the same study showed that Murrah milk had significantly higher concentrations of lysine, isoleucine, leucine, phenylalanine, cysteine, and histidine than Nili-Ravi milk.

In a separate three-breed comparison involving Murrah, Nili-Ravi, and Mediterranean buffaloes under identical housing and feeding conditions in China, Mediterranean buffalo milk had significantly higher fat and protein contents and the highest concentrations of sphingomyelin, cholesterol, and lanosterol. Murrah buffalo milk was distinguished by higher whey protein and total unsaturated fatty acid content, whereas Nili-Ravi milk exhibited higher total saturated fatty acids and specific casein fractions.

Jaffarabadi Buffalo Milk Composition Across Lactation Stages

Garaniya et al. (2013) evaluated the nutrient profile of Jaffarabadi buffalo milk across nine successive stages of lactation. Unlike breed-to-breed comparisons, this study primarily demonstrates the effect of lactation stage within a single breed.

Table 8. Changes in Jaffarabadi buffalo milk composition across nine lactation stages

Parameter	**Trend across lactation stages (1–9)**	**Significant variation?**
Fat (%)	Increased progressively as lactation advanced	Yes
pH, Protein, Density, SNF, Lactose	Remained largely stable	No
Iron, Copper (trace elements)	Remained nearly constant	No
Zinc, Manganese, Sodium	Varied significantly across stages	Yes
Potassium, Calcium (macro-elements)	Remained nearly constant	No

Source: *Garaniya et al. (2013),* Asian Journal of Dairy and Food Research, *32(2):168–170.*

Among the minerals evaluated, iron, copper, potassium, and calcium remained nearly constant across the nine lactation stages, whereas zinc, manganese, and sodium demonstrated significant stage-wise variation. These observations represent a within-breed lactation-stage effect rather than a direct comparison with another buffalo breed.

Consolidated Observations

The quantitative evidence reviewed in this article highlights several major patterns in the transition from buffalo colostrum to mature milk:

- Sodium showed the steepest macro-mineral decline, decreasing by approximately 75% from calving to Day 14.
- Copper showed the greatest decline among the measured micro-minerals, decreasing by approximately 89%, followed by iron at approximately 78%.
- Phosphorus was the most stable macro-mineral, changing by less than 2% between calving and Day 14.
- Vitamin E was more stable than vitamin A during the transition. Buffalo colostrum contained higher vitamin E but lower vitamin A concentrations than cow colostrum in the study considered.
- IgG and IgM decreased by more than 97% within five days, demonstrating the importance of early colostrum feeding for neonatal immune protection.
- Breed differences were measurable even at narrowly matched postpartum stages. Kundi buffalo colostrum showed higher fat, protein, and total solids than Nili-Ravi buffalo colostrum at 6 hours postpartum.

- Murrah buffaloes showed higher protein and total solids than Nili-Ravi buffaloes in the comparative studies considered, whereas Mediterranean buffaloes showed higher fat and specific lipid fractions.
- Jaffarabadi buffalo milk exhibited stage-dependent changes in fat and selected minerals, demonstrating that lactation stage can influence milk composition independently of breed effects.

Practical Implications

The quantitative changes documented in buffalo colostrum have important implications for calf management, dairy technology, and research.

For neonatal management, colostrum should ideally be provided to newborn calves as early as possible after birth. The rapid reduction in immunoglobulins during the first several days postpartum highlights the importance of timely colostrum intake, particularly during the first hours of life.

Breed-specific differences may also have implications for colostrum management. Kundi buffalo colostrum, for example, demonstrated higher fat, protein, and total solids than Nili-Ravi colostrum at 6 hours postpartum, whereas Jaffarabadi buffalo milk exhibited distinctive lactation-stage patterns. Such differences may need to be considered when developing breed-specific colostrum pooling, storage, or processing protocols.

From a dairy-processing perspective, relatively stable components such as phosphorus and vitamin E may be less sensitive indicators of the transition from colostrum to mature milk. In contrast, rapidly changing components such as sodium, copper, and immunoglobulins may provide more sensitive indicators of the stage of lactation and the progression from colostral to mature milk.

These observations may also be useful when designing future studies examining breed-specific milk composition, calf nutrition, colostrum quality, and the functional properties of buffalo milk.

Conclusion

The quantitative evidence reviewed from Egyptian, Murrah, Kundi, Nili-Ravi, Jaffarabadi, and Mediterranean buffalo studies demonstrates that the transition from colostrum to mature milk is rapid, measurable, and influenced by both lactation stage and breed.

Among the minerals evaluated, sodium and copper showed particularly pronounced declines, whereas phosphorus remained comparatively stable. Vitamin E exhibited greater stability than vitamin A. The most dramatic changes were observed among the immunological components, with IgG and IgM declining by more than 97% within the first five days postpartum.

Breed differences were also evident. Kundi buffaloes exhibited higher fat, protein, and total solids in colostrum than Nili-Ravi buffaloes at 6 hours postpartum. Murrah buffaloes demonstrated higher protein and total solids than Nili-Ravi buffaloes in comparative studies, while Mediterranean buffaloes exhibited higher fat and specific lipid fractions under the conditions reported. Jaffarabadi buffaloes demonstrated additional variation associated with lactation stage.

Overall, these quantitative data provide a useful reference framework for understanding the dynamic biochemical transition from buffalo colostrum to mature milk. The numerical values may assist researchers, students, veterinarians, dairy technologists, and animal scientists in designing further breed-specific and lactation-stage-specific investigations.

References

1. Abd El-Fattah, A. M., Abd Rabo, F. H. R., El-Dieb, S. M., & El-Kashef, H. A. (2012). Changes in composition of colostrum of Egyptian buffaloes and Holstein cows. *BMC Veterinary Research, 8*, 19. https://doi.org/10.1186/1746-6148-8-19
2. Dang, A. K., Kapila, S., Purohit, M., & Singh, C. (2009). Changes in colostrum of Murrah buffaloes after calving. *Tropical Animal Health and Production, 41*(7), 1213–1217. https://doi.org/10.1007/s11250-008-9302-7
3. Ahmad, S., Inayat, S., Nadeem, M., & Sheikh, A. A. (2024). Physicochemical and antimicrobial properties of colostrum and milk under transition state in Kundi and Nili Ravi buffalo breeds of Pakistan. *Journal of Population Therapeutics and Clinical Pharmacology, 31*(1), 1264–1276. https://doi.org/10.53555/jptcp.v31i1.4169
4. Zhou, L., Tang, Q., Iqbal, M. W., Xia, Z., Huang, F., Li, L., Liang, M., Lin, B., Qin, G., & Zou, C. (2018). A comparison of milk protein, fat, lactose, total solids and amino acid profiles of three different buffalo breeds in Guangxi, China. *Italian Journal of Animal Science, 17*(4), 873–878. https://doi.org/10.1080/1828051X.2018.1443288
5. Abdel-Hamid, M., Huang, L., Huang, Z., Romeih, E., Yang, P., & Zeng, Q. (2023). Effect of buffalo breed on the detailed milk composition in Guangxi, China. *Foods, 12*(8), 1603. https://doi.org/10.3390/foods12081603
6. Garaniya, N. H., Ramani, H. R., & Golakiya, B. A. (2013). Nutrient profile of Jaffarabadi buffalo milk at different stages of lactation. *Asian Journal of Dairy and Food Research, 32*(2), 168–170. https://arccjournals.com/journal/asian-journal-of-dairy-and-food-research/ARCC352
7. An, Z., Luo, G., Gao, S., Zhang, X., Chen, C., Yao, Z., Zhao, J., Lv, H., Niu, K., Nie, P., & Yang, L. (2023). Evaluation of parity effect on characteristics and minerals in buffalo (*Bubalus bubalis*) colostrum and mature milk. *Foods, 12*(6), 1321. https://doi.org/10.3390/foods12061321
8. Abdel-Hamid, M., Yang, P., Mostafa, I., Osman, A., Romeih, E., Yang, Y., Huang, Z., Awad, A. A., & Li, L. (2022). Changes in whey proteome between Mediterranean and Murrah buffalo colostrum and mature milk reflect their pharmaceutical and medicinal value. *Molecules, 27*(5), 1575. https://doi.org/10.3390/molecules27051575