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A Comparative Study of the Physicochemical Parameters of Human Breast Milk (HBM) with Milk Samples of Various Milch animals (Buffalo, Cow and Goat)

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Abstract: Milk is the viscous substance generated by the special glands called as mammary glands of various animals, including humans.These animals are known as Milch animals. Milch animals have a high milk production rate and were domesticated for their milk. Breast milk is the diet of choice for neonates due to its high toleration during the developmental and maturation stages of their digestive systems. The purpose of this study was to conduct a relative analysis of the physicochemical parameters found in milk samples obtained from various species of milch animals, including buffalo, cow, goat and human breast milk. The physiochemical parameters analysed of collected milk samples from various regions of Maharashtra, India, included presence of lactose, titratable acidity, and specific gravity. The specific gravity determined was 1.029±0.001, 1.033±0.004, 1.0231±0.005 and 1.027±0.002, in the milk samples collected from humans, buffalo, cow and goat, respectively. The pH determined was 7.16±0.132, 6.74±0.39, 6.61±0.05 and 6.64±0.55 in the milk samples collected from humans, buffalo, cow and goat, respectively. The titratable acidity determined was 0.11±0.01%, 0.20±0.02%, 0.16±0.01% and 0.15±0.01% in human, buffalo, cow and goat milk samples, respectively. The lactose levels present was 7.09±0.01%, 5.09±1.10%, 4.51±0.14% and 4.12±0.30% in milk samples of humans, buffalos, cow and goat, respectively. Additionally, total solids, ash, fat, and proteins in all the milk samples collected was also determined.

Keywords: Human Breast Milk, Milch animal, Phytochemical parameters

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Introduction

Milk is the viscous substance generated by the special glands called as mammary glands of various animals, including humans, is the only food of the young mammals during the first

period of their life (Hu *et al*., 2024). The optimal nutrition for neonates is breast milk, which has been refined over millions of years of evolution to precisely meet the needs of the infant. Human breast milk (HBM) is an extraordinarily intricate and highly variable biofluid that has developed over millennia to provide nourishment and disease protection for neonates until their immune systems mature (Andreas *et al*., 2015). The proportions of water, lipids, lactose, proteins, and minerals in milk vary among animal species (Pietrzak-Fiećko and Kamelska-Sadowska, 2020; Roy *et al*., 2020). Breast milk is composed of 87–88% water, 1% numerous complex proteins, 3.8% lipids, and 7% carbohydrates (Kim *et al*., 2020). The concentrations of milk undergo considerable changes during a single feeding and during the duration of breastfeeding, to fulfill the requirements of the newborn (Andreas *et al*., 2015). In addition to providing structural integrity, the chemicals that are included in milk also give the energy that is necessary for the growth of cells (Ballard and Morrow, 2013). Lactation is followed by a period of time during which variations in milk content continue to exist. In addition, the establishment of these disparities is greatly influenced by a variety of factors, including environmental circumstances, genetic variations, physiological processes, and dietary intake (Rutkowska *et al*., 2011). The milk from different animal source shows significantly variable levels of chemical components (Rafiq, 2016). HBM also provides immunity to the neonates due to presence of antibodies in it (Lars and Marina, 2002).

The milk is widely acknowledged as a high-quality food item and is well received by all individuals (Kanwal *et al*., 2004; Kanetkar *et al*., 2023,). It has been an indispensable component of existence throughout the entirety of human history, and it has played a crucial role in the development of human civilization (Ullah, 2022). India has the greatest milk production in the world, accounting for 24.64 per cent of the total milk output globally (Wu *et al*., 2018; Roy *et al*., 2022). This makes India the dairy producer with the highest production. According the data published by Press Information Bureau on December 2023, the production of milk has increased at a compound annual growth rate (CAGR) of 5.85% over the previous nine years, going from 146.31 million tonnes in 2014-2015 to 230.58 million tonnes in 2022-23. This is a significant increase from the year 2014-2015. The milking species of the world may be classified into two distinct categories: "Major" and "Minor" milking species. The buffalo and the cow are categorised as "Major milking species" (MaMS), whereas other milking species such as sheep, goat, camel, yak, horse, donkey, and reindeer are categorised as "Minor milking species" (MiMS) (Faccia *et al*., 2020).

This study aimed to evaluate the various physicochemical characteristics, such as pH, specific gravity, titratable acidity, total soluble solids (TSS), ash content, fat content, protein content, and lactose levels, of milk samples of humans and milch animals such as buffalo, cow, and goat. For this study milk samples of buffalo, cow and goat were collected from the different areas of Maharashtra, five samples collected from each species and human breast milk sample was collected from five women who delivered healthy babies.

Materials and Methods

Collection of samples:

Milk samples from buffalo, cow, and goat from different parts of Maharashtra were collected in sterile bottles. Human breast milk samples were collected from five women delivering healthy babies (written consent was obtained from them). These samples were stored at 4°C till further analysis.

Physicochemical analysis:

A digital pH meter was utilized to determine the precise pH of various milk samples. The meter is calibrated using pH 4 and 7 buffers to ensure accuracy. The specific gravity was determined by applying the method provided by Bari *et al*. (2015) which involves utilizing the lactometer

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

Sources of Milk	S-1	S-2	S-3	S-4	S-5	Mean	S.D
Human	7.00	7.40	7.10	7.10	7.20	7.16	0.13
Buffalo	6.70	6.98	6.53	6.66	6.84	6.74	0.39
Cow	6.55	6.70	6.60	6.57	6.67	6.61	0.05
Goat	6.60	6.82	6.48	6.58	6.74	6.64	0.55

S-1 = Sample 1 (Collected from Pune), S-2 = Sample 2 (Collected from Sambhaji Nagar), S-3 = Sample 3 (Collected from Nashik), S-4 = Sample 4 (Collected from Buldhana), S-5 = Sample 5 (Collected from Washim), SD = Standard Deviation.

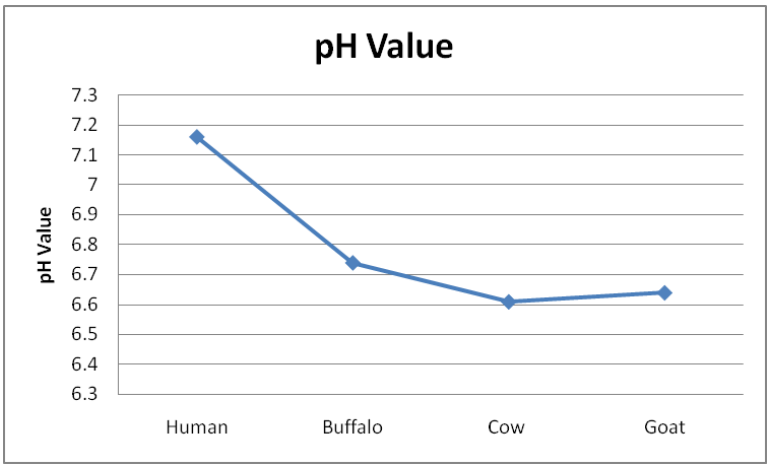

Fig. 1: Mean of pH values of milk samples collected from Human, buffalo, cow and goat.

reading [method: Milk density = 1 + (lactometer reading 1000-1)]. The titratable acidity was measured using the titrimetric technique outlined in the AOAC (2000) guidelines. The technique outlined by Ilirjana Boci *et al*. (2013) was used to determine the total solids and fat content. The ash content was quantified using a gravimetric approach, employing a muffle furnace set at a temperature of 550°C for a duration of 5 h, as outlined by Nweze and Nwagwe (2019). The protein content was determined using the formal titration method as reported by Clara (1977). The content of lactose in all twenty milk samples was assessed. The lactose content was determined using the Tritimetric technique with Felhing licor, following the procedure published by Simone *et al*. (2013).

Results and Discussion

pH: pH of Human breast milk samples and Milch animal milk sample 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 7.00-7.20 in HBM, 6.53-6.98 in buffalo milk, 6.55-6.70 in cow milk and 6.48-6.82 in goat milk. pH values of HBM were higher than all Milch animals. The results showed that pH values of Buffalo milk, cow milk and goat milk sample were different from each other. The graphical representation of mean is shown in Figure 1.

Specific Gravity: Specific gravity of milk samples collected from human breast milk, buffalo milk, cow Milk and goat Milk is given in Table 2. Specific gravity was found in range of 1.028-1.031 in HBM, 1.028- 1.040 in buffalo milk, 1.027-1.040 in cow milk and 1.024- 1.031 in goat milk. Specific gravity of buffalo milk was higher than of Human, cow and goat milk sample. Specific

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

Sources of Milk	S-1	S-2	S-3	S-4	S-5	Mean	S.D.
Human	1.030	1.031	1.028	1.029	1.030	**1.029**	**0.001**
Buffalo	1.031	1.037	1.040	1.028	1.030	**1.033**	**0.004**
Cow	1.040	1.027	1.029	1.031	1.029	**1.031**	**0.005**
Goat	1.026	1.029	1.031	1.028	1.024	**1.027**	**0.002**

S-1 = Sample 1 (Collected from Pune), S-2 = Sample 2 (Collected from Sambhaji Nagar),S-3 = Sample 3 (Collected from Nashik), S-4 = Sample 4 (Collected from Buldhana), S-5 = Sample 5 (Collected from Washim), SD = Standard Deviation.

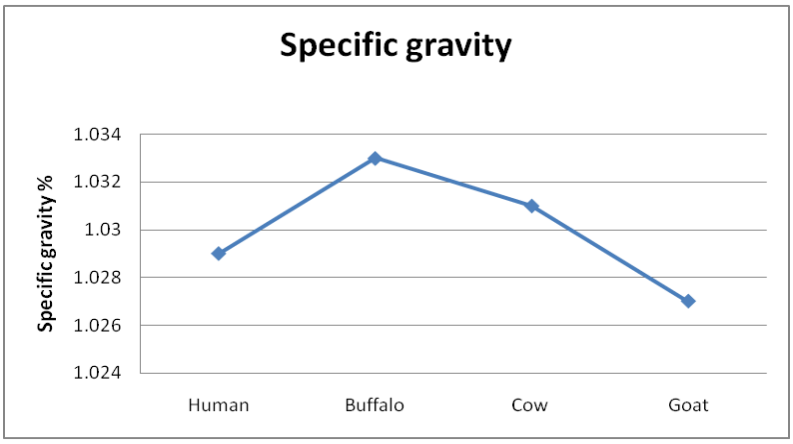

Fig. 2: Mean of specific gravity values of milk samples collected from Human, buffalo, cow and goat.

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

Sources of Milk	S-1	S-2	S-3	S-4	S-5	Mean	S.D.
Human	0.12	0.11	0.12	0.13	0.11	**0.11**	**0.010**
Buffalo	0.22	0.17	0.21	0.19	0.23	**0.20**	**0.027**
Cow	0.18	0.19	0.17	0.14	0.16	**0.16**	**0.018**
Goat	0.16	0.14	0.18	0.14	0.15	**0.15**	**0.015**

S-1 = Sample 1 (Collected from Pune), S-2 = Sample 2 (Collected from Sambhaji Nagar), S-3 = Sample 3 (Collected from Nashik), S-4 = Sample 4 (Collected from Buldhana), S-5 = Sample 5 (Collected from Washim), SD = Standard Deviation.

gravity of cow milk was also higher than that of human milk. The graphical representation of Specific gravity means is shown in Figure 2.

Titratable acidity: The values of titratble acidity of milk samples collected from Human Breast Milk, buffalo milk, cow Milk and goat Milk is given in Table 3. It was observed from results that the values of titratble acidity were in the range of 0.11- 0.13 % in HBM, 0.17- 0.22% in buffalo milk, 0.14-0.19% in cow milk and 0.14- 0.18% in goat milk. The values of titratable acidity of buffalo milk were higher than that of human, cow and

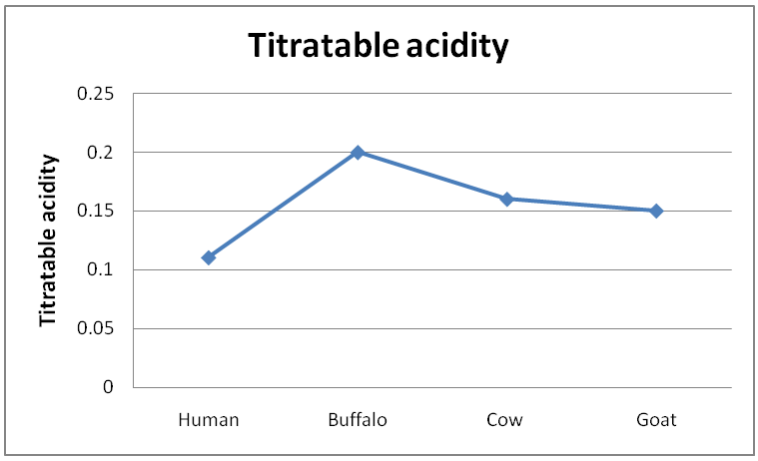

Fig. 3: Mean of titrable acidity values of milk samples collected from Human, buffalo, cow and goat.

Table 4: Total solid values of milk samples collected from Human, buffalo, cow and goat

Sources of Milk	S-1	S-2	S-3	S-4	S-5	Mean	S.D
Human	12.15	12.40	12.30	12.35	12.20	12.28	0.092
Buffalo	16.94	16.99	17.02	17.00	16.98	16.98	0.027
Cow	12.94	13.13	12.80	11.23	13.50	12.72	0.781
Goat	12.00	12.72	12.90	12.88	13.04	12.70	0.440

S-1 = Sample 1 (Collected from Pune), S-2 = Sample 2 (Collected from Sambhaji Nagar), S-3 = Sample 3 (Collected from Ahmad Nagar), S-4 = Sample 4 (Collected from Buldhana), S-5 = Sample 5 (Collected from Washim), SD = Standard Deviation.

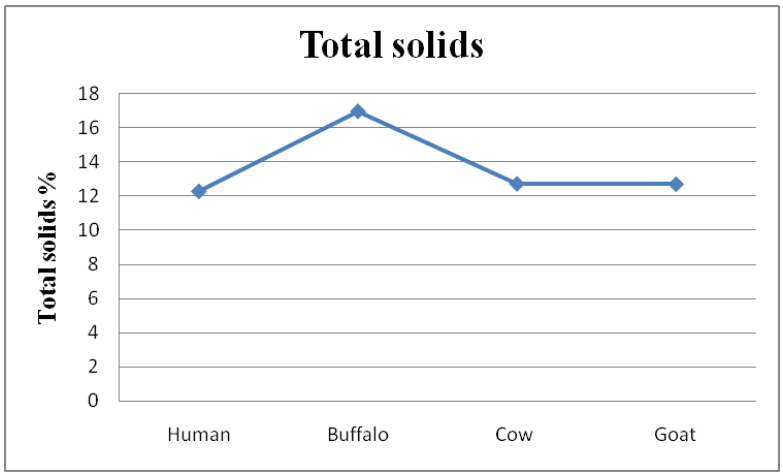

Fig. 4: Mean of total solid values of milk samples collected from Human, buffalo, cow and goat.

Table 5: Ash content values of milk samples collected from Human, buffalo, cow and goat

Sources of Milk	S-1	S-2	S-3	S-4	S-5	Mean	S.D.
Human	0.18	0.22	0.20	0.19	0.20	0.19	0.011
Buffalo	0.72	0.69	0.80	0.77	0.73	0.74	0.039
Cow	0.40	0.48	0.55	0.50	0.58	0.50	0.062
Goat	0.78	0.60	0.59	0.67	0.56	0.64	0.078

S-1 = Sample 1 (Collected from Pune), S-2 = Sample 2 (Collected from Sambhaji Nagar), S-3 = Sample 3 (Collected from Nashik), S-4 = Sample 4 (Collected from Buldhana), S-5 = Sample 5 (Collected from Washim), SD = Standard Deviation.

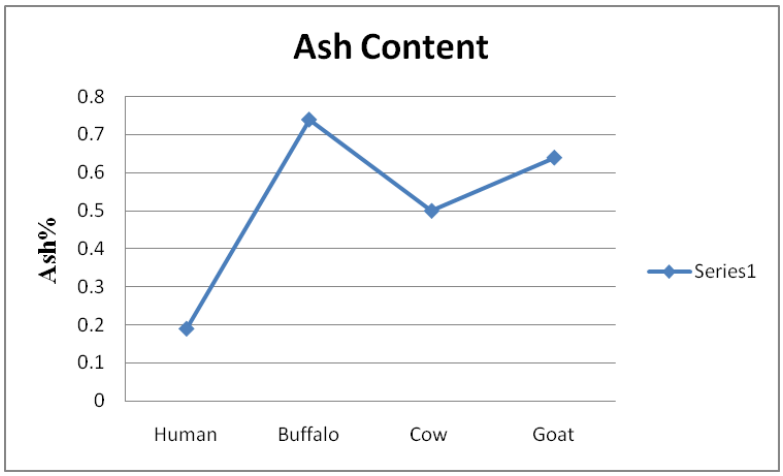

Fig. 5: Mean of Ash content values of milk samples collected from Human, buffalo, cow and goat.

Table 6: Fat content values of milk samples collected from Human, buffalo, cow and goat

Sources of Milk	S-1	S-2	S-3	S-4	S-5	Mean	S.D.
Human	4.37	4.44	4.40	4.40	4.36	4.39	0.028
Buffalo	7.20	7.10	7.00	6.99	7.13	7.08	0.079
Cow	3.69	3.44	4.00	4.21	4.07	3.88	0.278
Goat	3.60	3.78	3.95	3.16	3.55	3.60	0.264

S-1 = Sample 1 (Collected from Pune), S-2 = Sample 2 (Collected from Sambhaji Nagar), S-3 = Sample 3 (Collected from Nashik), S-4 = Sample 4 (Collected from Buldhana), S-5 = Sample 5 (Collected from Washim), SD = Standard Deviation.

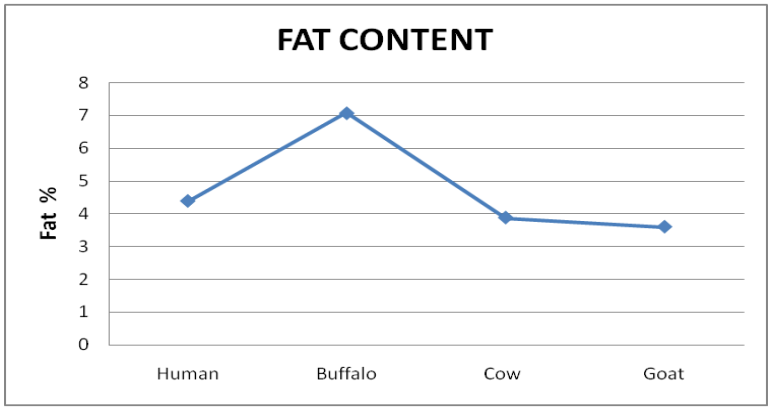

Fig. 6: Mean of fat content values of milk samples collected from Human, buffalo, cow and goat.

Table 7: Protein content values of milk samples collected from Human, buffalo, cow and goat

Sources of Milk	S-1	S-2	S-3	S-4	S-5	Mean	S.D.
Human	0.89	0.92	0.90	0.88	0.90	0.89	0.017
Buffalo	4.44	4.01	4.50	4.66	4.08	4.33	0.249
Cow	3.15	3.50	3.44	3.28	2.99	3.27	0.186
Goat	3.25	2.43	3.20	3.11	2.77	2.95	0.310

S-1 = Sample 1 (Collected from Pune), S-2 = Sample 2 (Collected from Sambhaji Nagar),S-3 = Sample 3 (Collected from Ahmad Nagar), S-4 = Sample 4 (Collected from Buldhana), S-5 = Sample 5 (Collected from Washim), SD = Standard Deviation.

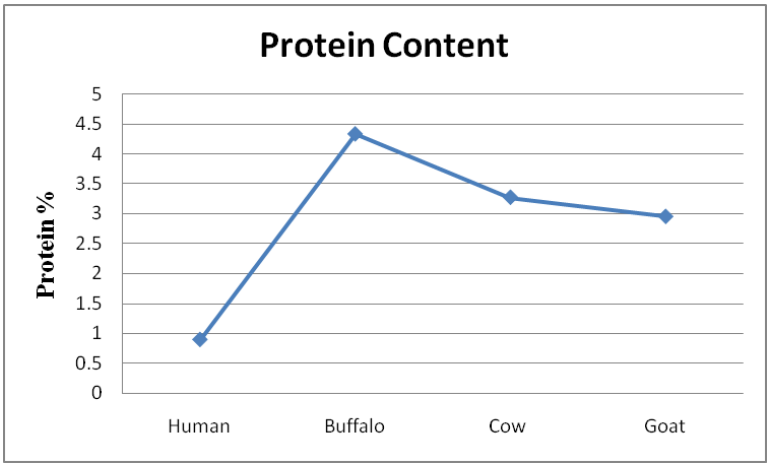

Fig. 7: Mean of protein content values of milk samples collected from Human, buffalo, cow and goat.

goat milk. The values of titratable acidity of human breast milk sample are lower than all three milch species. The graphical representation of titrable acidity mean is shown in Figure 3.

Total solids: The concentration of total solids in milk samples collected from Human Breast Milk, buffalo milk, cow Milk and goat Milk is given in Table 4. These results illustrated that the concentration of total solids was in range of 12.15- 12.40% in HBM, 16.98- 17.02% in buffalo milk, 11.23-13.50% in cow milk and 12.00-13.04% in goat milk. The values of total solid of buffalo milk was higher than that of human, cow and goat milk. The graphical representation of total solid mean is shown in Figure 4.

Ash: Ash content in milk samples collected from Human Breast Milk, buffalo milk, cow Milk and goat Milk is given in Table 5. The results of this study revealed that the ash content was in the range of 0.18-0.22 % in HBM, 0.69-0.80% in buffalo milk, 0.40-0.58% in cow milk and 0.56-0.78 % in goat milk. Ash content of human breast milk sample was lower than all three milch animals. The values of Ash content of buffalo milk were higher than that of human, cow and goat milk. The graphical representation of Ash content mean is shown in Figure 5.

Fat: Fat content in milk samples collected from human, buffalo, cow and goat is given in Table 6. Results illustrated that fat content was in the range of 4.36-4.44% in HBM, 6.99-7.20% in buffalo milk, 3.44-4.21% in cow milk and 3.16-3.78 % in goat milk. Fat content of breast milk sample was lower than buffalo milk and higher than cow and Goat milk sample.The graphical representation of fat content mean is shown in Figure 6.

Protein: Protein content in milk samples collected

Table 8: Lactose content values of milk samples collected from Human, buffalo, cow and goat

Sources of Milk	S-1	S-2	S-3	S-4	S-5	Mean	S.D.
Human	7.09	7.11	7.10	7.09	7.10	7.09	0.010
Buffalo	4.90	4.66	5.55	5.80	4.56	5.09	1.103
Cow	4.88	4.01	4.80	4.19	4.70	4.51	0.142
Goat	3.70	4.29	4.30	3.83	4.50	4.12	0.305

S-1 = Sample 1 (Collected from Pune), S-2 = Sample 2 (Collected from Sambhaji Nagar), S-3 = Sample 3 (Collected from Nashik), S-4 = Sample 4 (Collected from Buldhana), S-5 = Sample 5 (Collected from Washim), SD = Standard Deviation.

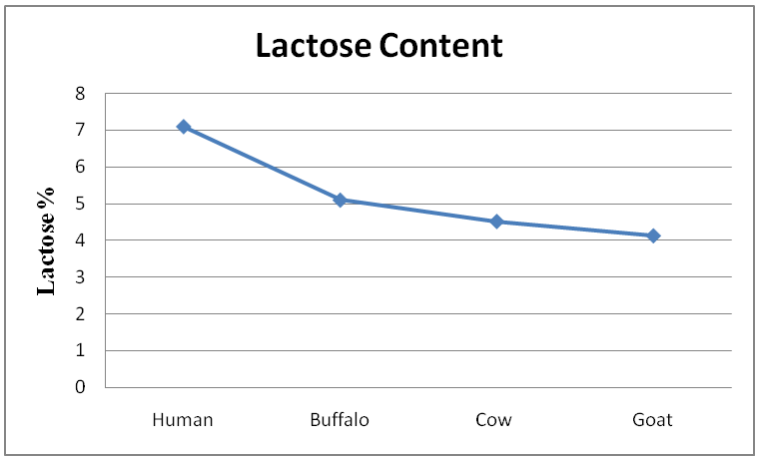

Fig. 8: Mean of lactose content values of milk samples collected from Human, buffalo, cow and goat.

from human, buffalo, cow and goat is given in Table 7. According to these results protein content was in range of 0.88-0.92% HBM, 4.01-4.66% in buffalo milk, 2.99-3.50% in cow milk and 2.43-3.25% in goat milk. Protein content of human breast milk sample is lower than all three milch animal. The graphical representation of protein content mean is shown in Figure 7.

Lactose: Lactose content in milk samples collected from human, buffalo, cow and goat is given in Table 8. Results illustrated that the lactose content was in range of 7.09-7.11% HBM, 4.56-5.80% in buffalo milk, 4.01-4.88% in cow milk and 4.29-4.50% in goat milk. Lactose content value in human breast milk sample was higher than all three milch animals. The graphical representation of lactose content mean is shown in Figure 8.

Conclusion

Milk and its derivatives have the potential to be a beneficial source of food for humans. The utilization of these resources can result in the production of individualized dairy products that are suited for people of all age groups. It is important to note that the content of milk differs depending on the animal from which it originates. This ensures that the young of that species are able to grow and develop at the appropriate rate. This study investigated the relative analysis of various parameters present in different milk samples collected from human breast and milch animals. pH and lactose of Human breast milk was

higher than buffalo, cow and goat milk. Human breast milk specific gravity is lower than buffalo and cow milk but higher than goat milk sample. Titrable acidity, ash and protein of human breast milk was lower than buffalo, cow and goat. All the tested parameters were higher in buffalo milk except pH and lactose.

Ethical Statement

This study was in accordance and guidelines with the Academic Research Committee (ARC) of the Annasaheb Awate Arts Commerce & Hutatma Babu Genu Science College, Manchar, Pune, Maharashtra, India.

Author Contributions

Ingole Dyaneshwar and *Punam Ingole* conceived and planned the experiments. *Shilpa Maskare*, *Abhay Aher* and *Pratik Chaudhari* carried out the experiments. *Ingole Dyaneshwar*, *Abhay Aher* and *Pratik Chaudhari* contributed to the interpretation and results. *Hemangi Gavit* took the lead in writing the manuscript. All authors discussed the results and agreed to the published manuscript.

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Conflict of Interest

The authors declare no conflicts of interest.

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