American Journal of Bioscience and Clinical Integrity
https://biojournals.us/index.php/AJBCI
ISSN: 2997-7347

Chemical Composition and Biological Properties of Colostrum and Milk Fed to Calves

H. S. O‘rinov, O. U. Kuldoshev, G.B.Ubaydullayeva, D. Eshimov
Department of Biology, Microbiology and Bioengineering, Zarmed University
haqberdiorinov@gmail.com

Received: 2025, 15, Nov
Accepted: 2025, 21, Dec
Published: 2026, 27, Jan

Annotation: This study investigates the chemical composition and biological properties of colostrum and milk fed to calves under farm conditions. Special attention was given to the dynamics of mineral components, particularly total calcium and inorganic phosphorus, during different stages of lactation. Milk and colostrum samples were collected at various post-calving periods and analyzed using standard biochemical methods. The results showed that the concentration of essential minerals gradually decreased as lactation progressed, which may negatively influence metabolic processes, skeletal development, and natural resistance in calves. Calcium and phosphorus deficiencies during early growth stages can lead to impaired physiological development and increased susceptibility to metabolic disorders. The findings highlight the importance of monitoring milk quality and implementing timely nutritional correction through balanced feeding and mineral supplementation of lactating cows. Ensuring adequate mineral and vitamin content in milk contributes to improved calf health, growth performance, and efficient utilization of genetic potential, thereby enhancing overall productivity in cattle farming systems.

Keywords: Natural resistance, biochemical composition, biological properties, Turner method, fat content, Gerber method, proteins, Kjeldahl method, sugars, Bertrand

method.

Introduction

Relevance of the Study

In many countries worldwide, various stress factors and unsanitary conditions—particularly inadequate nutritional balance and lack of exercise areas—contribute to the high incidence of postpartum gynecological diseases among high-yielding cows. These conditions often result in metabolic disorders and a decrease in natural resistance. One of the most common problems in high-producing cows is reproductive dysfunction, which primarily arises at peak lactation due to deficiencies of essential nutrients in the ration [1]. Consequently, milk and meat productivity decline, product quality deteriorates, reproductive performance worsens, physiologically underdeveloped calves are born, growth and development retardation occurs, and animals become unsuitable for herd replacement. These factors shorten the productive lifespan of cows, making this issue highly relevant for modern livestock farming [2].

Main Part

To determine the biochemical composition and biological properties of colostrum fed to calves in experimental farms, colostrum samples collected from cows on the first, fifth, and eighth days after calving were analyzed. The chemical composition of colostrum was assessed by determining acidity (Turner method), fat content (Gerber method), protein content (Kjeldahl method), sugar content (Bertrand method), and dry matter concentration.

The acidity of colostrum measured by the Turner method averaged 25.2 ± 1.2°T on the first day after calving (reference value: 39.9°T), 20.5 ± 1.3°T on the fifth day, and 22.4 ± 1.6°T on the eighth day. Similarly, the fat content of colostrum averaged 3.1 ± 0.8% on the first day, 2.8 ± 0.22% on the fifth day, and 2.7 ± 0.34% on the eighth day (Table 1).

The protein content of colostrum was recorded as 10.8 ± 1.24% on the first day (reference value: 14.8%), 6.4 ± 1.05% on the fifth day, and 3.3 ± 0.75% on the eighth day. A reduction in protein content of colostrum may negatively affect disease resistance and immune system development in newborn calves.

The sugar content of colostrum was 3.1 ± 0.17% on the first day (reference value: 3.6%), 3.0 ± 0.5% on the fifth day, and 3.2 ± 0.26% on the eighth day. The dry matter content averaged 16.8 ± 1.52% on the first day (reference value: 21.5%), 9.5 ± 0.62% on the fifth day, and 8.6 ± 1.8% on the eighth day.

***Table 1.* Chemical Composition of Colostrum Fed to Calves**

Indicators	Day 1	Day 5	Day 8
Acidity, °T	25.2 ± 1.2	20.5 ± 1.3	22.4 ± 1.6
Fat, %	3.1 ± 0.8	2.8 ± 0.22	2.7 ± 0.34
Protein, %	10.8 ± 1.24	6.4 ± 1.05	3.3 ± 0.75
Milk sugar (lactose), %	3.1 ± 0.17	3.0 ± 0.50	3.2 ± 0.26
Dry matter, %	16.8 ± 1.52	9.5 ± 0.62	8.6 ± 1.80

Based on these indicators, a decrease in the biological value of colostrum obtained from cows affected by metabolic disorders, raised under unfavorable geo-ecological conditions, and kept under inadequate housing and feeding conditions was observed.

Endemic microelementosis in pregnant cows leads to the birth of weak calves with low natural resistance, physiologically underdeveloped (hypotrophic), and highly susceptible to diseases [3-4].

Milk is considered the most nutritionally complete natural food. Its composition includes carbohydrates, phosphatides, neutral fats, sterols, various proteins, vitamins, minerals, enzymes, and water. More than 200 substances have been identified in milk, including approximately 40 mineral elements, about 20 amino acids, over 60 fatty acids, 17 vitamins, numerous enzymes, and hormones. Milk proteins are among the most easily digestible and contain essential amino acids that cannot be replaced by other nutrients. Casein constitutes about 82% of total milk protein and is its primary protein fraction. Milk contains enzymes such as lipase, proteinase, xanthine oxidase, alkaline phosphatase, catalase, aldolase, and others [5-6].

The principal carbohydrate in milk is lactose ($C_{12}H_{22}O_{11}$), a disaccharide accounting for about 5% of cow's milk. Milk lipids include triglycerides, diglycerides, and monoglycerides. Fat-soluble vitamins A, D, and E, as well as provitamin carotene, are present in milk, while water-soluble vitamins include B-group vitamins (B_1, B_2, B_3, B_6, B_{12}) and vitamin C (ascorbic acid). Scientists have established that cow's milk contains almost all chemical elements of the D.I. Mendeleev periodic table [7].

The average chemical composition of cow's milk (per 100 mL) is as follows: vitamin A – 0.025 mg, vitamin D – 0.05 µg, vitamin E – 0.09 mg, calcium – 122 mg, phosphorus – 92 mg, total protein – 3.3 g, fat – 3.6 g, and casein – 2.6 g [8-9].

The content of vitamins and minerals in milk is one of the key indicators for assessing vitamin–mineral metabolism in calves. Therefore, in the present study, to determine biologically active substances in milk fed to calves during A- and D-hypovitaminosis, milk samples were collected from cattle farms in districts of the Republic of Karakalpakstan and analyzed under laboratory conditions for vitamin and mineral composition [10].

Laboratory analysis of milk samples fed to calves showed that in livestock farms of Qiziltepa district, Navoi region, milk fat content in Farm 1 averaged 3.48 ± 0.64% in the first month of lactation and 3.25 ± 0.38% in the third month. In Farm 2, milk fat content averaged 3.44 ± 0.50% and 3.20 ± 0.24%, respectively; in Farm 3, 3.60 ± 0.38% and 3.46 ± 0.57%; and in Farm 4, 3.52 ± 0.66% and 3.26 ± 0.47% (reference value: 3.8%) [11-12].

The total protein content of milk in Farm 1 averaged 3.3 ± 0.20% in the first month of lactation and 2.9 ± 0.38% in the third month; in Farm 2, 2.9 ± 0.31% and 2.7 ± 0.36%; in Farm 3, 3.3 ± 0.25% and 3.0 ± 0.44%; and in Farm 4, 3.1 ± 0.55% and 2.8 ± 0.63% (reference range: 2.7–5.0%) ($P < 0.05$) [13].

The vitamin content of milk from Farm 1 was characterized by a relative decrease. **Retinol concentration averaged** 0.96 ± 0.02 µg% in the first month of lactation and 0.72 ± 0.03 µg% in the third month. In Farm 2, retinol levels were 0.88 ± 0.05 µg% and 0.65 ± 0.04 µg%; in Farm 3, 0.94 ± 0.07 µg% and 0.73 ± 0.05 µg%; and in Farm 4, 0.98 ± 0.07 µg% and 0.78 ± 0.09 µg% (reference range: 1.3–3.15 µg%) [14].

Vitamin E (tocopherol) content in milk from Farm 1 averaged 8.2 ± 0.07 µg% in the first month of lactation and 7.5 ± 0.06 µg% in the third month. Corresponding values in Farm 2 were 8.4 ± 0.05 µg% and 7.3 ± 0.04 µg%; in Farm 3, 8.7 ± 0.02 µg% and 7.5 ± 0.06 µg%; and in Farm 4, 8.5 ± 0.09 µg% and 7.4 ± 0.02 µg% (reference range: 8–10 µg%).

Total calcium content in cow's milk decreased from the first to the third month of lactation. **In Farm 1, calcium content averaged** 126.8 ± 2.5 mg% and 120.4 ± 2.3 mg%; in Farm 2, 124.6 ± 2.2 mg% and 118.9 ± 3.5 mg%; in Farm 3, 131.2 ± 2.53 mg% and 124.5 ± 3.3 mg%; and in Farm 4, 128.2 ± 2.1 mg% and 121.3 ± 2.6 mg%.

The inorganic phosphorus content in milk averaged 61.2 ± 1.5 mg% in the first month of lactation and 54.6 ± 2.4 mg% in Farm 1; 57.8 ± 2.6 mg% and 51.3 ± 2.7 mg% in Farm 2; 59.3 ± 2.5 mg% and 52.8 ± 2.4 mg% in Farm 3; and 62.9 ± 2.2 mg% and 53.7 ± 2.2 mg% in Farm 4 [15].

Conclusion

The analysis of the mineral composition of milk fed to experimental calves revealed a gradual decrease in the levels of total calcium and inorganic phosphorus throughout the lactation period. These changes indicate that as lactation progresses, the mineral value of milk declines, which may negatively affect bone formation, metabolic stability, and overall physiological development of calves. Calcium and phosphorus play a key role in skeletal growth, enzyme activity, neuromuscular regulation, and energy metabolism; therefore, their deficiency during early postnatal development can predispose calves to metabolic disorders, growth retardation, and reduced natural resistance.

The obtained results confirm that monitoring the mineral composition of milk is essential for assessing the nutritional adequacy of calf diets, especially under conditions of intensive dairy farming. The observed reduction in calcium and inorganic phosphorus emphasizes the need for timely nutritional correction through balanced feeding strategies, including mineral and vitamin supplementation of cows during lactation. Ensuring optimal mineral content in milk allows for better utilization of the genetic potential of calves, improves health status, and reduces the risk of hypocalcemia, hypophosphatemia, and associated metabolic diseases. Therefore, the findings of this study provide a scientific basis for developing effective feeding programs aimed at improving calf growth, survivability, and long-term productivity in cattle farming systems.

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