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***Original Article***

# Mare's Milk: Composition, Properties, and Application in Medicine

**Musaev, A[1]*, Sadykova, S[2], Anambayeva, A[1], Saizhanova, M[1], Balkanay, G[1], Kolbaev, M[1]**

*1. NJSC"Asfendiyarov Kazakh National Medical, University", Almaty, Kazakhstan*
*2. Kazakh Medical University of Continuing Education, Almaty, Kazakhstan*

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Corresponding Author: musaev.dr@mail.ru

**Abstract**

Mare's milk is a highly valuable organic substance that has a great potential to replace cow's milk. Consumption of cow's milk causes digestive disorders in some individuals. Immunoglobulin E (IgE)-mediated cow's milk allergy (CMA) is one of the most common food allergies among infants. Therefore, finding a protein substitute with the same nutritional value is a priority. Mare's milk can be a good substitute for cow's milk, especially for those suffering from CMA. Prerequisites for this study were the recent interest in mare's milk, as an ancient relic of the Turkic peoples which contains lots of nutrients. The present study aimed to systematize relevant information on the composition of mare's milk and its application in medicine. Google Scholar, PubMed, Cochrane, Elsevier, CyberLeninka were employed for a comprehensive literature search. The searched keywords for this study were mare's milk, saumal, composition, properties, use in medicine. A total of 77 sources were selected for reviewing the literature. Most sources were in English, except for one of the bottom 40 sources published in the last 10 years. Among the milk of many mammalian species, mare's milk is chemically similar to human milk so it can be used as a substitute. It is also used to feed people with various health conditions, especially in patients at risk, or suffering from tuberculosis, hepatitis C, psoriasis, and various types of immunodeficiency. The present study describes the rich composition, antibacterial and antiviral properties of mare's milk. A review of the literature revealed that mare's milk is an excellent thirst quencher, and has valuable nutrients necessary for the human body which is by no means inferior to human milk.

**Keywords:** Antibacterial property, Antiviral property, Composition, Mare's milk

## 1. Introduction

Mare's milk is the most important nutritional resource for foals during the first months of life and the human population in areas of central Asia (Mongolia and the southern states of the former Soviet Union, such as Kazakhstan, Tajikistan, Kyrgyzstan) where lactic alcoholic beverages called kumis (1) and saumal are traditionally produced through fermentation (2). These products are used in Russia and Mongolia for managing digestive and cardiovascular diseases. Equine milk is recommended as a substitute for bovine milk for children who suffered from cow's milk allergy (CMA) in Italy (3).

Genetic, physiological, nutritional, and environmental conditions affect the composition of mammalian milk. Some researchers have compared the composition of mare's milk to human milk. The amount of protein in the mare's milk is more than that of human milk and less than cow's. The concentration of casein in mare's milk is between human milk and cow's. The fat of mare's milk is lower than human and cow's milk, however, they are similar in the distribution of

diglycerides and triglycerides. The proportion of unsaturated fatty acids in human and mare's milk is much higher than in cow's milk. Mare's milk has some structural and functional properties that can be used in human nutrition (4).

Holmes, Spelman (5) experimented with mare's milk compounds to determine water, protein, ascorbic acid, phosphorus, potassium, magnesium, and calcium. They showed that milk was produced in the early lactation period in late winter and early spring when mares fed mainly on alfalfa and cereals. The average amount of mare's milk was 89.7% water, 2.3% protein, and 89 mg ascorbic acid. Mare's milk contains 63 mg of phosphorus, 64 mg of potassium, 9.0 mg of magnesium, and 102 mg of calcium per liter. Holmes et al. reported that this amount per 100 grams of mare's milk, is higher than that of cow's, goat's, ewe's, buffaloe's, camel's, or human milk. Mare's milk has less protein than other types of milk, however, more than that of human milk. Ascorbic acid in mare's milk is more than that in cow's, goat's, or human milk. Its phosphorus is less than cow's or goat's milk, however, more than that of human milk and has only about one-third of the potassium in cow's or goat's milk. It has also less magnesium and calcium than cow's or goat's milk, however, about four times as much as human milk. The ratio of calcium and phosphorus in mare's milk is much higher than cow's or goat's milk, however, probably lower than that of human milk (5). Csapó-Kiss, Stefler (6) performed experiments on 29 lactating mares and reported that total protein, whey protein, casein, and NPN content were 16.41, 13.46, 2.95, and 0.052, respectively, for colostrum immediately after calving.

Limited information is available on the amino acid composition of colostrum and mare's milk. The amino acid composition of mare's milk proteins, except for Arginine and Threonine, is relatively similar to that of ruminants (7). However, other researchers reported that the amino acid composition of mare's milk differs from that of other farm animals due to its higher Cysteine and Glycine content. Mare's milk contains high Serine and Glutamic acid, and low Methionine (8).

The present study aimed to review the available scientific literature over the past ten years regarding mare's milk as a valuable food source and to investigate the potential of this organic matter.

## 2. Material and Methods

A comprehensive literature search was performed in the databases of Google Scholar, PubMed, Cochrane, Elsevier, CyberLeninka. The searched keywords for this study were mare's milk, saumal, composition, properties, use in medicine. Inclusion criteria were the availability of information on the composition, properties, and use of mare's milk in medicine.

A total of 152 articles were found based on the results of the search among which 70 articles only written in English and Russian were selected according to specific criteria related to the subject of this study.

## 3. Results and Discussion

Mare's milk is not organoleptically similar to cow's milk (4, 9). It is clearer, whiter, and sweeter than cow's milk, which makes it similar to human milk (10). The content of the main components of mare's milk differs greatly from that of cow's or human milk (Table 1). Each component of the mare's milk has been comprehensively considered and compared with human milk and cow's milk in the present study.

**Table 1.** Composition of mare's, cow's, and human milk

| Component | Fat (%) | Protein (%) | Lactose (%) | Ash (%) | Energy (kcal/kg) |
|---|---|---|---|---|---|
| Mare's milk | 1.21 | 2.14 | 6.37 | 0.42 | 480 |
| Cow's milk | 3.61 | 3.25 | 3.25 | 0.76 | 674 |
| Human milk | 3.64 | 1.42 | 6.71 | 0.22 | 677 |

### 3.1. Fat

The fat content of the mare's milk is significantly lower than that of human and cow's milk (4, 11) (Figure 1). Mare's milk is mainly composed of medium-chain fatty acids, human milk has a high concentration of long-chain fatty acids, while cow's milk is rich in short-chain fatty acids (9). The ratio of unsaturated-to-saturated fatty acids in mare's milk (1:3) is close to that in human milk (1:2), whereas it deviates from the typical values of cow's milk (2:1). Mare's milk is a good source of linoleic acid (n-6 acid) and α-linolenic acid (n-3 acid) (12), which are not synthesized by the human body and are essential for developing the nervous system (13).

Mare's milk contains fewer triglycerides, however, it is 9 and 5 times richer in free fatty acids (FFA) and phospholipids, respectively, which are necessary for cell membranes (14). In this way, it may save the cell wall from oxidative phosphorylation.

### 3.2. Proteins

According to recent studies (4, 15), mare's milk is similar to human milk in terms of protein composition, 8.30%, and 7.60% respectively (16). The percentage of whey protein in mare's milk is 20% higher than that in cow's milk compared to other fractions (Figure 2). The whey protein content in mare's milk is approximately 40%, which is lower than that in human milk (4, 15). Cow's milk has the highest amount of caseins, so it is called casein type milk, whereas mare's and human milk are called albumin type milk (4, 17). Since cow's milk contains a lot of caseins (coarse proteins), it usually develops allergies in infants (18). Additionally, mare's milk contains more albumins (finely dispersed), therefore it does not develop allergies (9). High levels of whey protein and exogenous amino acids in mare's milk are more beneficial sources of nutrients for humans than cow's milk (19).

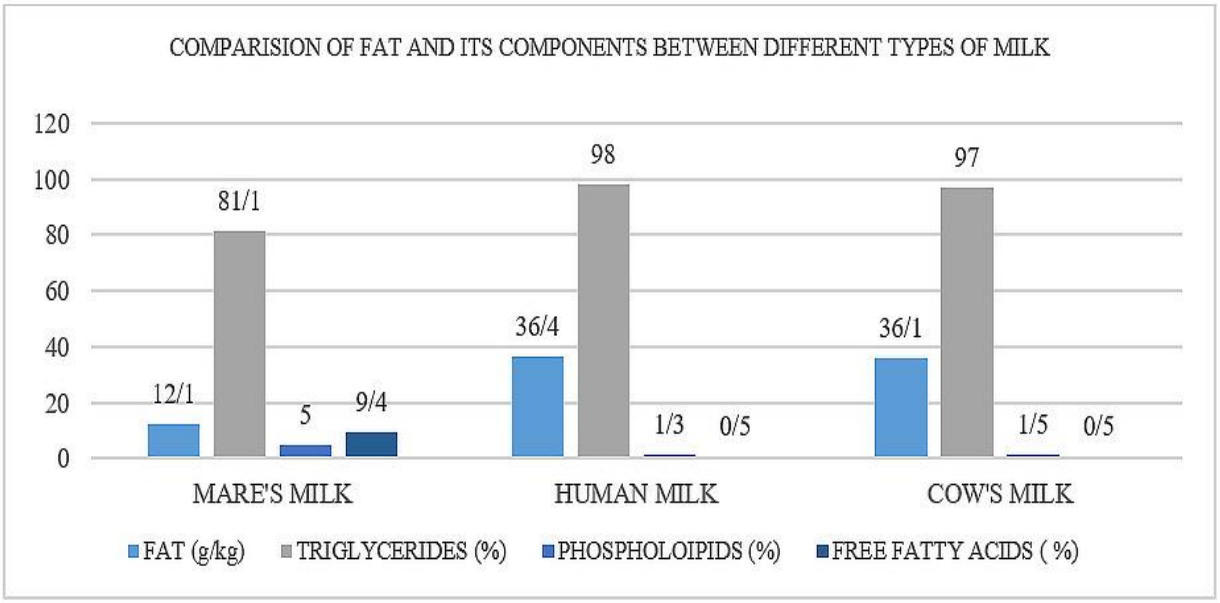


**Figure 1.** Comparison of fat and its components between different types of milk

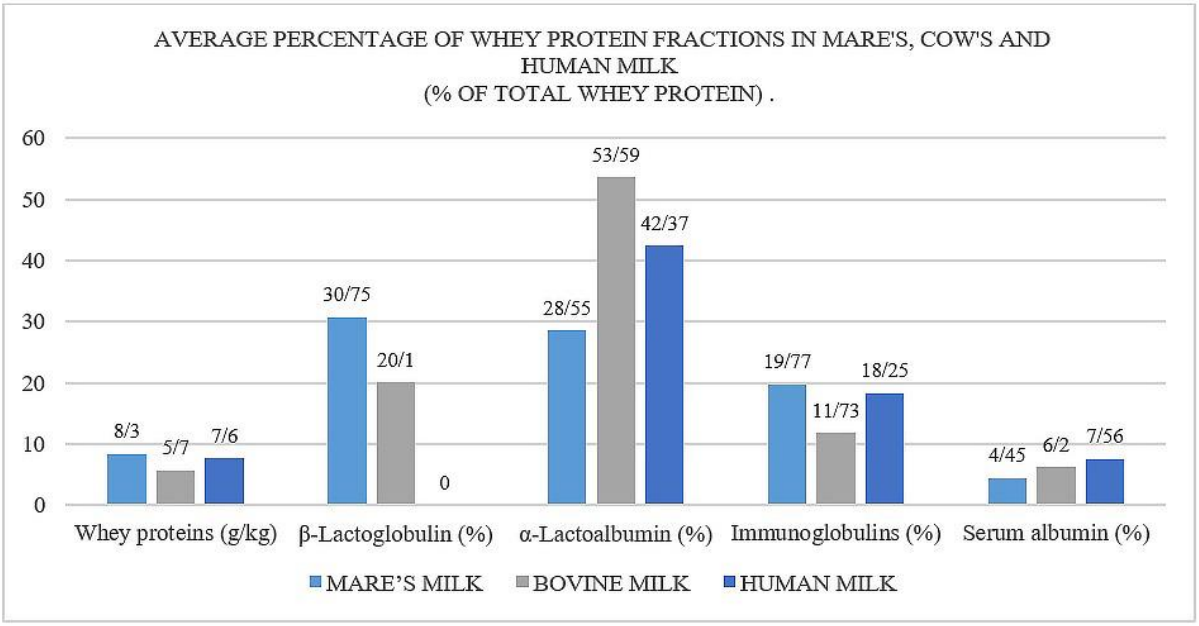


**Figure 2.** The average percentage of whey protein fractions in mare's, cow's and human milk (% of total whey protein)

### 3.3. Amino Acids

Amino acids are essential constituents of foods. They supply the building blocks required for protein biosynthesis (20). About 300 amino acids are found in cells and tissues of living organisms, however, only 20 of them serve as links (monomers) from which the peptides and proteins of all organisms are built (21). Based on their nutritional/physiological roles, amino acids can be differentiated as 1. Essential amino acids (valine, leucine, isoleucine, phenylalanine, tryptophan, methionine, threonine, histidine (essential for infants), lysine, and arginine "semi-essential"); 2. Nonessential amino acids (glycine, alanine, proline, serine, cysteine, tyrosine, asparagine, glutamine, aspartic acid, and glutamic acid) (22).

Mare's milk is a better nutritional source for humans than cow's milk due to a high percentage of whey proteins and exogenous amino acids (6, 23) (Table 2).

The quantity of Asparagine, Threonine, Serotonin, Proline, Leucine, and Lysine in Mare's milk is almost 6 times and the level of glutamine is 3 times higher than those of cow's milk. Furthermore, the Glutamine level is 3 times higher. However, human milk indexes are 10 times higher in all points, which proves its importance for the development of the musculoskeletal system of infants.

### 3.4. Carbohydrates and Lactose

Carbohydrates are also present in form of oligosaccharides which make the surface of the external layer of lipid globules. They form a branched structure similar to human milk which is not found in cow's milk. Such a structure is likely to slow down the transportation of fat through the gastrointestinal system, allowing longer activity of bile salts and lipase (24).

Human milk contains slightly more lactose (6.71%) than mare's milk (6.37%). This is the main source of carbohydrates (23). Lactose can be supplied to an organism only as a constituent of milk. Lactose can influence the process of seeding of the gastrointestinal tract with microorganisms responsible for its breakdown (25, 26). This can lead to a symbiosis in which favorable microflora is established to compete and exclude many potential pathogens (24).

Galactose contained in lactose participate in the rapid development of the brain and myelination in young organisms, which require significant amounts of galactosylceramides and galactolipids (24). Therefore, galactose plays a unique role in providing the

requirements for rapid development of the infant brain (27).

### 3.5. Vitamins

Recent studies (19, 22) have been proven that mare's milk contains vitamins A, D3, E, K2, C, B1, B2, B3, B6, B12. The content of these vitamins in mare's and cow's milk does not differ significantly (19) (Table 3). Mare's milk is much richer in vitamin C as compared to cow's milk which has a high nutritional value due to its resistance to oxidation and anti-inflammatory properties. Mare's milk contains a similar level of vitamin A compared to cow's milk, however, some authors (16) pointed out that this amount is lower than that of human milk. Recent studies have shown that vitamin D is found in greater amounts in mare's milk than that of human milk (19). According to Glade (28), vitamin D supplementation significantly decreases the risk of premature death and death from cancer as well as supporting general health. Mare's milk is characterized by an average concentration of vitamins from the B group, while human milk and cow's milk contain less and more vitamins, respectively, compared to that of mare's milk (Table 3). The level of cobalamin is higher and vitamins B2 and B9 are lower in mare's milk compared to human and cow's milk (22, 24). Additionally, the level of Vitamin K is almost 9 times higher than human milk, which means that it has a positive effect on the coagulation system.

**Table 2.** Composition of essential and non-essential amino acids content (g/100g milk) in mare's, cow's and human milk

| Amino acid | Mare's milk | Cow's milk | Human milk |
|---|---|---|---|
| **Essential amino acids** | | | |
| His | 0.492 | 0.10 | 2.50 |
| Ile | 0.492 | 0.14 | 6.09 |
| Leu | 1.444 | 0.29 | 10.02 |
| Lys | 1.444 | 0.27 | 6.33 |
| Met | 0.213 | 0.06 | 2.94 |
| Phe | 0.738 | 0.16 | 4.48 |
| Thr | 1.132 | 0.15 | 4.22 |
| Trp | 0.229 | 0.05 | - |
| Val | 0.853 | 0.16 | 5.17 |
| **Non-essential amino acids** | | | |
| Asp | 1.543 | 0.26 | 9.85 |
| Ser | 1.444 | 0.16 | 3.6 |
| Glu | 2.281 | 0.77 | - |
| Pro | 1.346 | 0.32 | - |
| Gly | 0.558 | 0.06 | - |
| Ala | 0.673 | 0.10 | 5.03 |
| Cys | 0.164 | 0.02 | 0.99 |
| Ile | 0.492 | 0.14 | 6.09 |
| Tyr | 0.771 | 0.15 | 4.19 |
| Arg | 0.706 | 0.11 | 3.91 |

**Table 3.** Composition of fat-soluble and water-soluble vitamins in mare's, cow's and human milk

| Vitamins | Mare's milk | Human milk | Cow's milk |
|---|---|---|---|
| Vitamin A (mg/l) | 0.403 | 0.455 | 0.435-0.799 |
| Vitamin B1 (µg/l) | 20-40 | 14-17 | 28-90 |
| Vitamin B2 (µg/l) | 10-37 | 20-60 | 115-202 |
| Vitamin B3 (µg/l) | 70-140 | 147-178 | 50-120 |
| Vitamin B5 (µg/l) | 277-300 | 184-270 | 260-490 |
| Vitamin B6 (µg/l) | 30 | 11-14 | 30-70 |
| Vitamin B9 (µg/l) | 0.13 | 5.2-16 | 1-18 |
| Vitamin B12 (µg/l) | 0.3 | 0.03-0.05 | 0.11 |
| Vitamin C (µg/l) | 1280-8100 | 3500-10000 | 300-2300 |
| Vitamin D3 (µg/l) | 4.93 | 0.03-0.12 | 2.31-15.39 |
| Vitamin E (mg/l) | 1.13 | 5.09 | 1.05-1.95 |
| Vitamin K2 (µg/l) | 17.93 | 1.8 | 4.81-17 |

### 3.6. Minerals

Milk is generally a good source of calcium and phosphorus which are necessary for bone growth, as well as magnesium, which is needed for bone mineralization (15).

Research analysis indicated that mare's milk contains relatively few minerals compared to cow's milk (Table 4) (29). However, its calcium-to-phosphorus ratio (1.6–1.8:1) is more favorable to the proper skeletal growth of young organisms than that of cow's milk (approximately 1.4:1) and is closer to that in human milk (approximately 1.9:1) (15).

Research has shown that cow's milk contains about 50% more non-ionized $Ca^{2+}$, however, mare's milk has about twice more ionized $Ca^{2+}$ than human milk (22). The $Ca^{2+}$ to $P^{+}$ ratio of human and mare's milk are reported to be more favorable for intaking $Ca^{2+}$ compared to that in cow's milk, because it is ionized, which means is not connected with proteins and is easily digested.

The highest amount of sodium and potassium is found in cow's milk (30). Sodium in the form of cations plays an important role as a constituent of blood and extracellular fluid, and potassium as a cation participates in maintaining the integrity of intracellular fluid (31).

However, microelements concentration is low in all kinds of milk (22).

**Table 4.** Composition of minerals content (mg/100 ml milk) in mare's, cow's and human milk

| Mineral component | Mare's milk | Human milk | Cow's milk |
|---|---|---|---|
| $Ca^{2+}$ | 50–135 | 28–34 | 112–123 |
| $P^{+}$ | 20–121 | 14–43 | 59–119 |
| $K^{+}$ | 25–87 | 53–62 | 106–163 |
| $Na^{+}$ | 8–85 | 10–18 | 58 |

### 3.7. Antimicrobial Activity

Analysis of the literature indicated that mare's milk has broad antimicrobial and antiviral effects (28, 29). The antimicrobial activity of mare's milk is maintained by its lysozyme and lactoferrin (32).

Lysozyme, also called N-acetylmuramidase or muramidase, is a hydrolyze-type enzyme that catalyzes the peptidoglycan polymers of the bacterial cell wall at the 1-4 bond between N-acetylmuramic (NAM) acid and N-acetylglucosamine (NAG) residues, thereby lysing sensitive bacteria (33). Lysozyme was first discovered by Flemming (1922) in the nasal mucus and subsequently purified from various plant, animal, and microbial materials (bacteria, virus, and fungi) (28, 29).

Antibacterial activity of lysozyme is essentially directed towards gram-positive bacteria, as their target cell-wall component (peptidoglycan) is freely accessible to the enzyme, unlike gram-negative bacteria, which are protected by the lipopolysaccharide (LPS) layer of the outer membrane (33). In addition to bacteria, lysozyme has also been reported to inhibit viruses (HIV) and eukaryotic micro-organisms such as parasites (Entamoeba histolytica trophozoites) and fungi (Candida albicans) despite the absence of typical peptidoglycan in their envelopes (33).

The bactericidal properties of lysozyme are primarily attributed to its *N*– acetyl-muramoy-L-hydrolase enzymic activity, resulting in peptidoglycan hydrolysis and cell lysis. Lysozyme catalyzes the hydrolysis of the β-(1,4)-glycosidic linkage between N-acetylglucosamine and muramic acid of the peptidoglycan in the bacterial cell wall (30)**,** interacts with the lipopolysaccharide (LPS) layer in the outer membrane, and subsequently distorts the normal packing between phosphate groups of phospholipids and LPS by its polycationic properties. The distortion results in the perturbation of the outer membrane structure and the stimulation of the susceptibility to lysozyme of the peptidoglycan layer (9).

Lactoferrin is Another component of mare's milk that gives it great antimicrobial activity (Figure 4). It is an iron-binding glycoprotein from the transferrin family which is found in most biological fluids and is a major component of the mammalian innate immune system. The antibacterial activity of LF has been widely documented in vitro and in vivo for Gram-positive bacteria (*Bacillus stearothermophilus, Bacillus subtilis, Clostridium sp., Haemophilus influenza*) and Gram-negative bacteria (*Listeria monocytogenes, Micrococcus sp., Staphylococcus aureus, Streptococcus mutans*) and in some acid-alcohol-resistant bacteria (*Mycobacterium tuberculosis*) (34).

The bacteriostatic function of lactoferrin (LF) is maintained by its ability to withdraw the $Fe^{3+}$ ion, limit its usage by bacteria, and inhibit growth. The bactericidal function of LF is due to its direct interaction with the bacterial cell wall. In 1988, it was opened that LF damages the outer membrane of Gram-negative bacteria by interacting with lipopolysaccharide (LPS). The positively charged N-terminus of LF prevents the interaction between LPS and bacterial cations ($Ca^{2+}$ and $Mg^{2+}$), releasing LPS from the cell wall, increasing the membrane permeability, and damaging the bacteria. The interaction of LF and LPS also potentiates the action of previously discussed natural antibacterials, such as lysozyme (35).

According to recent research (17), the quantity of lysozymes in mare's milk is higher than that of other types of milk (Figure 3).

Figure 4 shows the average concentration of lysozyme in the milk of different mammals, which proves the high antiviral activity of mare's milk (24). Mare's milk contains the highest amount of lysozyme (98.9 mg/l), while human milk has 5 times less (21.39 mg/l).

Based on this quality, nowadays, mare's milk is used in various fields such as treatment and prevention of Tuberculosis and other bacterial infections, and use as a supplement to infant nutrition.

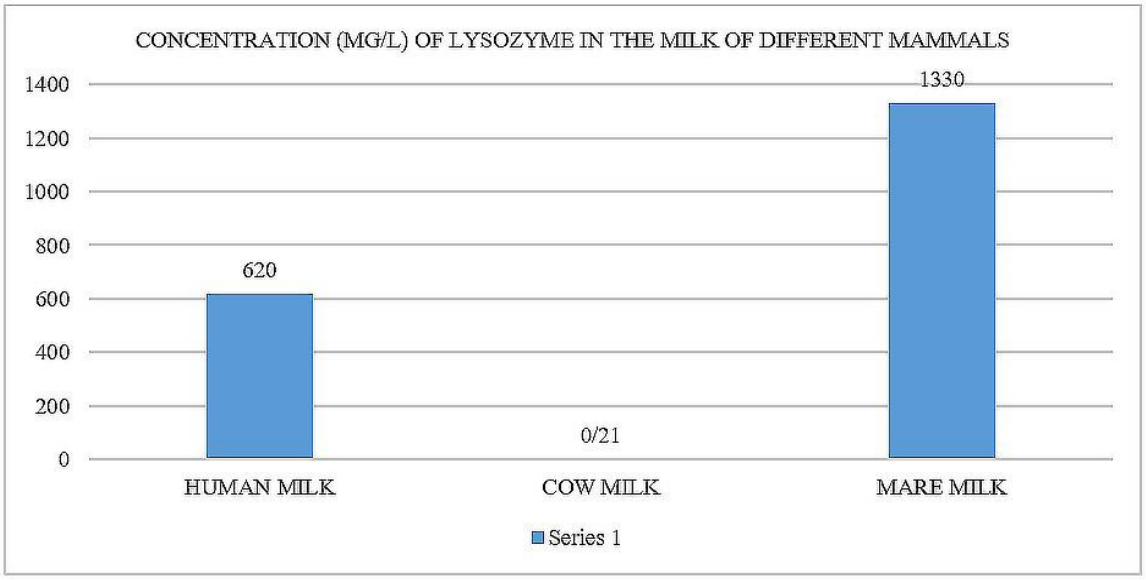


**Figure 3.** Concentration (mg/l) of lysozyme in the milk of different mammals

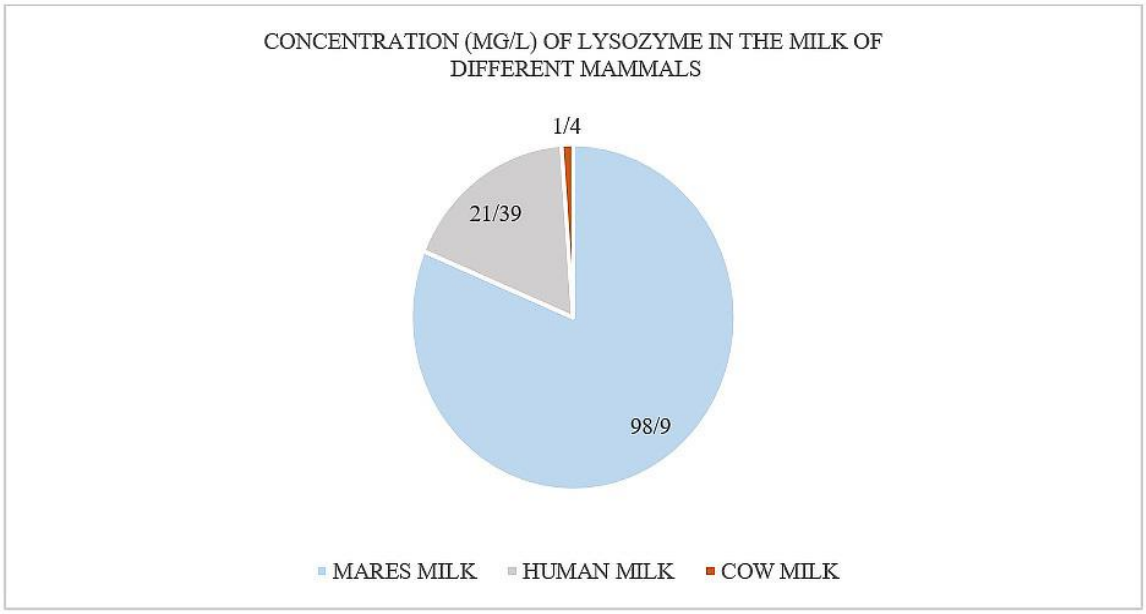


**Figure 4.** Concentration (mg/l) of lysozyme in the milk of different mammals

### 3.8. Antiviral Activity

A review of the literature showed that several constituents in mare's milk may have potential antiviral effects. Proteins of the innate immune system (lysozyme, lactoperoxidase, LF), specific immunoglobulins (IgM, IgG, and secretory IgA), lipid components, cytokines or prostaglandins help in the protection (36). Subsequent studies have shown that at least part of the antiviral properties of mare's milk can be attributed to the direct antiviral activity of LF. LF comprises antiviral activity against a wide range of human and animal viruses, both RNA and DNA viruses. This property will be discussed below in the example of HCV (37).

Hepatitis C virus (HCV) is a member of the Flaviviridae family. HCV is an enveloped virus that contains a positive, single-strand RNA genome. A unique feature of HCV is its ability to cause a persistent infection. Therefore, HCV is associated with the cause of chronic hepatitis, liver cirrhosis, and hepatocellular carcinoma. Limited information is available on the infection and maturation processes of HCV due to the lack of an in vitro culture system. Recently (24, 37) employed two different human-derived cell lines for the replication of HCV. An antiviral effect of LF on HCV replication was observed using these culture systems (37).

LF can prevent adsorption to target cells by binding to the envelope proteins of HCV E1 and E2. In addition, it was shown that LF interferes with the binding of HCV E2 in vivo since anti-human LF antibodies, were able to co-precipitate secreted and intracellular forms of E2 in the presence of LF, which were transiently expressed in HepG2 cells. Following other studies, time of addition assays indicated that LF probably interferes with adsorption of HCV to the target cells: it is most effective if administered before or simultaneous with the viral inoculum (37).

Recent research has shown that LF also works against rotavirus, friend virus, poliovirus, respiratory syncytial virus, HIV, herpes simplex virus types 1,2, and cytomegalovirus (37). This property of Mare's milk makes it a valuable product in autumn and winter to prevent and strengthen the immune system.

Saumal has long been a popular gourmet food with an exceptionally delicious flavor and subtle nuances which is not found in any typical dairy product in Central Asia. Based on the analysis of data and review findings, it was found that mare's milk quenches thirst and also provides valuable nutrients for the human body. It is rich in proteins and carbohydrates, however, low in fat, which makes it a dietary product. Mare's milk is the best source of nutrients compared to cow's milk due to the high percentage of whey proteins and exogenous amino acids. The high content of vitamin C confirms its importance and value in immunomodulation. A high concentration and optimal ratio of $Ca^{2+}$ and $P^{+}$ was also detected in the mare's milk. During the review, its antibacterial and antiviral effects, as well as its effectiveness against Tuberculosis and Hepatitis C were given due to its lysozyme and lactoferrin. Although many beneficial effects and applications have been identified in medicine, there is the prospect of discovering other components of mare's milk and examining its effectiveness in various diseases in the future.

### Authors' Contribution

Study concept and design: A. M. and S. S.
Acquisition of data: A. A.
Analysis and interpretation of data: A. M. and M. S.
Drafting of the manuscript: G. B.
Critical revision of the manuscript for important intellectual content: M. K.
Statistical analysis: A. M.
Administrative, technical, and material support: S. S.

### Conflict of Interest

The authors declare that they have no conflict of interest.

### References

1. Pietrzak-Fiećko R, Tomczyński R, Smoczyński SS. Effect of lactation period on the fatty acid composition in

mares' milk from different breeds. Arch Anim Breed. 2013;56(1):335-43.
2. Akai Tegin R, Gonulalan Z. All aspects of natural fermented products–koumiss. MANAS J Eng. 2014;2(1):23-34.
3. Wszolek M, Kupiec-Teahan B, Guldager HS, Tamime A. Production of kefir, koumiss and other related products. Fermented Milk. 2006:174-216.
4. Malacarne M, Martuzzi F, Summer A, Mariani P. Protein and fat composition of mare's milk: some nutritional remarks with reference to human and cow's milk. Int Dairy J. 2002;12(11):869-77.
5. Holmes AD, Spelman AF, Smith CT, Kuzmeski JW. Composition of mares' milk as compared with that of other species. J Dairy Sci. 1947;30(6):385-95.
6. Csapó-Kiss Z, Stefler J, Martin T, Makray S, Csapó J. Composition of mares' colostrum and milk. Protein content, amino acid composition and contents of macro and micro-elements. Int Dairy J. 1995;5(4):403-15.
7. Sarkar BR, Rykala AJ, Duncan C. The essential amino acid content of the proteins isolated from milk of the cow, ewe, sow, and mare. J Dairy Sci. 1953;36(8):859-64.
8. Duisembaev K, Akimbekov B. Variation of milk yield and its relationship with milk composition of mares at a koumiss farm. Sborn Nauch Trudov Kazakh Nauch-Issled Tekhnol Inst Ovtsev. 461982. p. 95-100.
9. Potočnik K, Gantner V, Kuterovac K, Cividini A. Mare's milk: composition and protein fraction in comparison with different milk species. Mljekarstvo: časopis za unaprjeđenje proizvodnje i prerade mlijeka. 2011;61(2):107-13.
10. Castellote C, Casillas R, Ramírez-Santana C, Pérez-Cano FJ, Castell M, Moretones MG, et al. Premature delivery influences the immunological composition of colostrum and transitional and mature human milk. J Nutr 2011;141(6):1181-7.
11. Claeys W, Verraes C, Cardoen S, De Block J, Huyghebaert A, Raes K, et al. Consumption of raw or heated milk from different species: An evaluation of the nutritional and potential health benefits. Food Control. 2014;42:188-201.
12. Collomb M, Schmid A, Sieber R, Wechsler D, Ryhänen E-L. Conjugated linoleic acids in milk fat: Variation and physiological effects. Int Dairy J. 2006;16(11):1347-61.
13. Zhang Y, Du R, He Q, Li H. Effect of Lactobacillus casei Zhang administration on liver lipids metabolism of high-Fat diet induced hypercholesterolemia rats. Sci Agric Sin. 2012;45:943-50.
14. Devle H, Vetti I, Naess- Andresen CF, Rukke EO, Vegarud G, Ekeberg D. A comparative study of fatty acid profiles in ruminant and non- ruminant milk. Eur J Lipid Sci Technol 2012;114(9):1036-43.
15. Xue Q-G, Schey KL, Volety AK, Chu F-LE, La Peyre JF. Purification and characterization of lysozyme from plasma of the eastern oyster (Crassostrea virginica). Comp Biochem Physiol B, Biochem Mol Biol. 2004;139(1):11-25.
16. Pecka E, Dobrzański Z, Zachwieja A, Szulc T, Czyż K. Studies of composition and major protein level in milk and colostrum of mares. Anim Sci J. 2012;83(2):162-8.
17. Sarwar A, Enbergs H, Klug E. Influences of parity, age and mineral and trace element mixture on lysozyme activity in mare's milk during early lactation period. Vet Arh. 2001;71(3):139-47.
18. Nwaru BI, Takkinen H-M, Niemelä O, Kaila M, Erkkola M, Ahonen S, et al. Timing of infant feeding in relation to childhood asthma and allergic diseases. J Allergy Clin Immunol. 2013;131(1):78-86.
19. Markiewicz-Kęszycka M, Wójtowski J, Czyżak-Runowska G, Kuczyńska B, Puppel K, Krzyżewski J, et al. Concentration of selected fatty acids, fat-soluble vitamins and β-carotene in late lactation mares' milk. Int Dairy J. 2014;38(1):31-6.
20. Garcia-Rodenas CL, Affolter M, Vinyes-Pares G, De Castro CA, Karagounis LG, Zhang Y, et al. Amino acid composition of breast milk from urban chinese mothers. Nutrients. 2016;8(10):606.
21. Marchis Z, Longodor AL, Balta I, Aurelia C. Influence of Lactation on Composition of Mare's Milk. Scientific Bulletin Series F Biotechnologies. 2019.
22. Belitz H-D, Grosch W, Schieberle P. Amino acids, peptides, proteins. Food chemistry: Springer; 2004. p. 8-91.
23. EFSA. The community summary report on trends and sources of zoonoses and zoonotic agents and food-borne outbreaks in the European Union in 2012. EFSA. 2014;12.
24. Sheng Q, Fang X. Bioactive components in mare milk. Bioactive Componentsin Milk Dairy Product. 2009:195.
25. Claeys WL, Cardoen S, Daube G, De Block J, Dewettinck K, Dierick K, et al. Raw or heated cow milk

consumption: Review of risks and benefits. Food Control. 2013;31(1):251-62.
26. Rahimi E, Kheirabadi EK. Detection of Helicobacter pylori in bovine, buffalo, camel, ovine, and caprine milk in Iran. Foodborne Pathog Dis. 2012;9(5):453-6.
27. Barłowska J, Szwajkowska M, Litwińczuk Z, Król J. Nutritional value and technological suitability of milk from various animal species used for dairy production. Compr Rev Food Sci Food Saf. 2011;10(6):291-302.
28. Glade MJ. A 21st century evaluation of the safety of oral vitamin D. Nutrition. 2012;28(4):344-56.
29. Pieszka M, Łuszczyński J, Zamachowska M, Augustyn R, Długosz B, Hędrzak M. Is mare milk an appropriate food for people?: a review. Ann Anim Sci. 2016;16(1).
30. Xu M, Wang Y, Dai Z, Zhang Y, Li Y, Wang J. Comparison of growth and nutritional status in infants receiving goat milk–based formula and cow milk–based formula: a randomized, double-blind study. J Food Nutr Res. 2015;59(1):28613.
31. Sarsekova F, Saparbekova A, Mamaeva L. Biochemical and microbiological bases of koumiss production with the introduction of highly active ferment. Issledovaniya, Resultaty. 2013;3:68-74.
32. Andersen JH, Osbakk SA, Vorland LH, Traavik T, Gutteberg TJ. Lactoferrin and cyclic lactoferricin inhibit the entry of human cytomegalovirus into human fibroblasts. Antiviral Res. 2001;51(2):141-9.
33. Benkerroum N. Antimicrobial activity of lysozyme with special relevance to milk. Afr J Biotechnol. 2008;7(25).
34. Naert L, Vande Vyvere B, Verhoeven G, Duchateau L, De Smet S, Coopman F. Assessing heterogeneity of the composition of mare's milk in Flanders. Vlaams Diergeneeskundig Tijdschrift. 2013;82(1):23-30.
35. Ellison R, 3rd, Giehl TJ. Killing of gram-negative bacteria by lactoferrin and lysozyme. J Clin Investig. 1991;88(4):1080-91.
36. Hamosh M. Protective function of proteins and lipids in human milk. Neonatology. 1998;74(2):163-76.
37. van der Strate BWA. Anti-cytomegalovirus applications of the intrinsically active drug carrier lactoferrin: University Library Groningen][Host]; 2001.