

# Improving the composition of mare's milk as a raw material for specialized products

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**Abstract.** This article presents research data conducted to improve the composition of mare's milk as a safe raw material for food production. The problem of producing specialized products is very acute and requires a solution. The Republic of Bashkortostan, as a region of developed dairy horse breeding, is a leading region in the production of mare's milk. This raw material is promising for the production of new types of food. To develop technology for new types of milk-based nutrition, it is necessary to improve the composition of this raw material by introducing additives containing microelements into the diet of mares. We propose the use of Sel-Plex additive, containing selenium in organic form. The following were determined: the selenium content in mare's milk, the physico-chemical composition of milk, the vitamin composition of milk, as well as the content of heavy metals. The findings indicate an improvement in the quality of mare's milk and the possibility of creating new types of specialized products based on it, including for nutrition of athletes. To increase the nutritional properties of mare's milk, it is recommended to use the selenium-containing additive Sel-Plex in its production at a rate of 1 g. per 100 kg of live weight.

## 1 Introduction

Nutritious and safe food is a source of nutrients the body needs and contributes to long-term human development. Access to sufficient, safe and nutritious food is essential to sustain life and promote health. According to the World Health Organization (WHO), unhealthy diets and decreased physical activity in children and adolescents are of particular concern. The health and nutrition of mothers and young children before and during pregnancy is important for the prevention of noncommunicable diseases throughout the lifespan. Moreover, beyond purely humanitarian aspects, maintaining the health and productivity of a growing older population is an important factor in reducing the demand for and costs of health services. Of course, nutrition and physical activity affect health, both together and separately. The listed categories can be combined into population groups whose nutrition should be different depending on age, health status and physical activity. Analysis of a number of data shows that there are significant differences in the volume of

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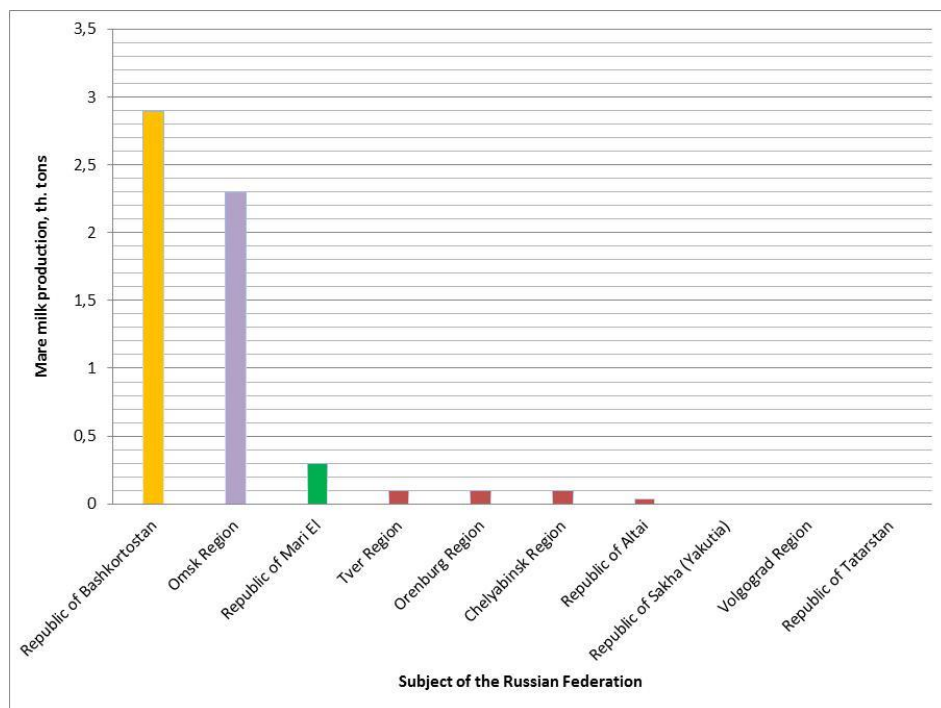
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food consumed by these groups. People involved in sports can also be identified as a separate group: they need to strengthen the protein-carbohydrate component of their diet. Such enhancement is possible due to certain types of raw materials for specialized nutrition[1].

The strategy for improving the quality of food products in the Russian Federation until 2030 is focused on ensuring adequate nutrition, preventing diseases, increasing the duration and quality of life of the population, stimulating the development of production and circulation of food products of adequate quality on the market. One of the goals of this strategy is the priority development of scientific research in the field of nutrition, including in the field of prevention of the most common non-communicable diseases and the development of production technologies aimed at improving the quality of food products [1-2].

The Republic of Bashkortostan is one of the few regions that have developed their own food security strategy. It should be noted that one of the strengths of the Republic is its developed agriculture and processing industry. The Republic of Bashkortostan is one of the largest agricultural regions of the Russian Federation, where dairy raw materials are processed at approximately 90 enterprises of various capacities. Traditionally, dairy horse breeding has been developed in Bashkortostan, the main product of which is mare's milk. At the present stage, this industry is an important reserve in the production of specialized products, mainly for children's, sports and dietary nutrition [8].

According to Rosstat, Bashkortostan ranks first in the Russian Federation in the production of mare's milk (Figure 1) and second in the number of horses (Table 1).



**Fig. 1.** Production of mare's milk in the Russian Federation, thousand tons (2023).

As can be seen from the diagram, the production of mare's milk in Bashkortostan amounted to 2.9 thousand tons in 2023.

**Table 1.** Number of horses in the Russian Federation (5 leading regions), thousand heads.

<b>Region</b>	<b>Livestock, thousand heads</b>
The Republic of Sakha (Yakutia)	181.1
Republic of Bashkortostan	125.8
Altai Republic	113.5
Transbaikal region	110.3
Tyva Republic	99.5

Mare's milk is a unique raw material with therapeutic and prophylactic properties, but these properties are currently not fully appreciated. In our country there are many examples of the use of mare's milk at the household level for feeding infants and treating various diseases, but there is no experience in producing it for food purposes specifically for certain groups of the population. The production of this product in large volumes, including for export, is not an easily solvable problem. A new type of enterprise with high technical skills and a hygienic production culture is needed. The import-substituting, export-oriented, environmentally friendly, clean and natural products produced by them will be in demand and will bring great benefits to the health of the population [5].

Over the past few years, interest in the use of mare's milk for human nutrition has increased, especially in France and Germany (Drogoul, Prevost, & Maubois, 1992). Recently, mare's milk has also been studied in Italy as a possible substitute for cow's milk or as a formula for allergic children (Businco et al., 2000; Curady, Giampietro, Lucenti, & Orlandi, 2001), as well as with the aim of finding new uses for local horse breeds (Pinto, Faccia, Di Summa, & Mastrangelo, 2001). The gross composition of mare's, women's and cow's milk shows significant quantitative differences in terms of nutritional value. The whole protein system of mare's milk is very similar to human milk. Whey protein concentrations in general and NPN are comparable [4]. The fat content of mare's milk is very low compared to human and cow's milk. Lipids in milk are dispersed as emulsified globules; in mare's milk, fat is organized into globules about 2-3  $\mu\text{m}$  in size [12]. Compared to human and cow's milk, mare's milk has a lower energy value due to less fat, while the sugar content of mare's and human milk is similar. In terms of the content of whole protein and salts, mare's milk is similar to women's milk, while cow's milk, which is richer in salts, is less suitable for replacing mother's milk [4].

The main product of mare's milk processing is kumiss, a product of alcoholic and lactic acid fermentation. Bashkiria is a region where kumis treatment and kumiss therapy historically originated. There are several climatic anti-tuberculosis sanatoriums in Bashkiria: Aksakovo, Shafranovo and Yumatovo. These sanatoriums have horse breeding farms and workshops for the production of kumys, which is used year-round. Currently, a promising direction is to improve the composition of mare's milk [6].

Improving the composition of mare's milk as a raw material for the production of specialized nutrition for certain groups of the population (athletes, nursing mothers, children, elderly people) is possible through the use of certain additives in the process of its production. Sel-Plex could be such an additive. Sel-Plex contains organic selenium compounds and is highly bioavailable compared to inorganic sources of selenium. The biological role of selenium is determined by its ability to replace vitamin E, enhance the production of endogenous antioxidants in proteins and lipids, influence the processes of tissue respiration and the immunobiological reactivity of the body. Selenoamino acids are easily absorbed by the body and are used in the synthesis of functional proteins, and also enter tissues as structural proteins, helping to increase selenium reserves in a useful form.

Sel-Plex contains 1000 mg/kg selenium, of which more than 98% is selenomethionine, selenocysteine and other organic selenium compounds [7-8].

The literature reviewed provided information on the effects of Sel-Plex supplementation containing selenium on the performance and reproduction of cattle, horses, poultry and swine. The inclusion of the selenium-containing additive Sel-Plex in horse diets will allow the use of selenium-enriched mare's milk in production. This will undoubtedly improve the consumer properties of this product and provide new opportunities for the economic development of dairy horse breeding [11]. The Republic of Bashkortostan is one of the selenium-deficient regions of Russia. Therefore, the problem of balancing horse feeding rations with selenium to increase the production of high-quality, environmentally friendly, selenium-enriched horse breeding products for specialized nutrition is relevant and requires an early solution [8].

In light of solving this problem, the purpose of our research was to study the effect of introducing selenium in organic form into the horse feeding diet on the quality of mare's milk as a raw material for the production of specialized products. The objectives of the study were: assessment of the effect of selenium on the physicochemical parameters of the resulting milk, assessment of selenium content, vitamin composition and heavy metal content.

## **2 Materials and methods**

The studies used open sources of international statistics: Statista, Research and Development-Our World in Data, FAO (Food and Agriculture Organization of the United Nations), reports and global nutrition strategy of WHO (World Health Organization), Strategy for improving the quality of food products in Russian Federation until 2030.

The experiments were carried out in the spring-autumn period of the year at JSC Ufa Stud Farm No. 119, and in the laboratory of the Department of Technology of Meat, Dairy Products and Chemistry of the Federal State Budgetary Educational Institution of Higher Education Bashkir State Agrarian University. The optimal dose of Sel-Plex supplementation into the diet of horses was determined by previous studies conducted in the laboratory of productive horse breeding and kumiss making of the Bashkir Scientific Research Institute of Agriculture, a separate structural unit of the Federal State Budgetary Institution UFITs RAS [9].

The object of the study was mare's milk obtained from dairy mares of the Bashkir breed starting from the third month of lactation. To identify the effect of the Sel-Plex additive on the quality of mare's milk, experimental and control groups of analogue mares by age and foaling date were formed. The control groups received the main diet, and the experimental groups received the main diet with the addition of Sel-Plex at the rate of 1 g. per 100 kg of live weight. The experiment was carried out from the beginning of the milking season until its end [10].

The main physicochemical and microbiological indicators of mare's milk were determined by standard methods generally accepted in research practice, focusing on the technical regulations of the Customs Union "On the safety of milk and dairy products" (TR CU 033/2013) (as amended on September 23, 2022).

The mass fraction of fat was determined according to GOST 5867-92, protein - GOST 25179-90 and GOST 23327-90, density - with a hydrometer according to GOST 3625, titratable acidity - according to GOST 3624-92. Temperature determination was carried out according to GOST 26754, purity groups - according to GOST 8218.

The content of selenium and toxic elements (lead, cadmium, etc.) was determined by electrothermal atomic absorption spectrometry according to MUK 4.1.986, vitamins -

according to GOST 7047 and liquid chromatography methods. Data processing was carried out using generally accepted methods of statistical analysis.

### 3 Results and Discussion

Table 2 presents average data on the chemical composition of milk collected over the entire lactation period for the control and experimental groups.

**Table 2.** Physico-chemical parameters of mare's milk by groups ( $\bar{X} \pm S\bar{x}$ ).

Index	Group	
	control	experienced
Density, kg, m <sup>3</sup>	1032±0.01	1030±0.01
Titrated acidity, OT	8.68±0.21	8.04±0.33
Mass fraction of fat, %	1.12±0.04	1.22±0.02**
Mass fraction of protein, %	1.99±0.17	2.07±0.14**
Mass fraction of dry skimmed milk residue (SMR), %	8.53±0.11	8.62±0.08**
Mass fraction of lactose,%	6.28±0.23	6.30±0.22
Phosphorus content, mg%	44.30±0.09	45.22±0.12
Calcium content, mg%	82.29±2.40	84.59±3.01

(\*\*) – P> 0.999

Analysis of the data presented in Table 2 showed the following: the average fat and protein content in the milk of mares in the experimental group increased by 0.08% and 0.10%, respectively. The concentration and indicators of lactose were approximately at the same level in all samples of both groups. Phosphorus and calcium content also increased by 0.92% and 2.30%, respectively. Milk proteins are characterized by the fact that they bind with phosphorus and calcium into a single complex, as well as the specificity of their colloidal structure [13]. An increase in the mass fraction of protein led to an increase in the content of these elements.

As part of the study, the drug Sel-Plex was used to improve the composition of milk, which was administered to animals in the feed at the rate of 1 g per 100 kg of live weight [9]. Table 3 shows data on selenium content in mares' milk during the experimental period.

**Table 3.** Selenium content in mare's milk, µg/l, ( $\bar{X} \pm S\bar{x}$ ).

Period	Group		%
	control	experienced	
Beginning of the experiment (spring)	17.09±0.21	17.07±0.44	- 0.12
Mid-experiment (summer)	18.39±0.41	24.75±0.32	+ 35.22
End of the experiment (autumn)	18.19±0.53	24.89±0.81	+ 37.19

Analysis of the data presented in Table 3 allowed us to obtain the following results: the milk of mares in the control group in the spring before the experiment contained 17.09 µg/l of selenium, and in the experimental group – 17.07 µg/l. There was no significant difference between the groups. During the milking period, as the animals absorbed the supplement, the selenium content in milk increased by 35% in the middle and 37.2% at the end of the experiment compared to the spring content. Thus, the addition of Sel-Plex to the diet of dairy mares resulted in the fortification of milk with selenium.

One of the objectives of the study was to determine the effect of Sel-Plex supplementation on the content of microelements, including heavy metals, in milk during

the experimental period. Table 4 presents data on the presence of heavy metals in milk samples during the experimental period.

**Table 4.** Content of trace elements in mare's milk, mg/kg.

Group	Name of metal					
	copper	zinc	ferrum	cobalt	plumbum	cadmium
beginning of the experiment (spring)						
Control	0.27	1.81	1.60	0.05	0.056	0.11
Experienced	0.42	1.96	1.57	0.05	not detected	0.01
mid-experiment (summer)						
Control	0.2	1.62	not detected	not detected	0.07	not detected
Experienced	not detected	1.30	not detected	not detected	0.07	not detected
end of the experiment (autumn)						
Control	0.12	1.70	0.58	0.09	not detected	not detected
Experienced	0.01	1.85	1.25	0.0041	not detected	not detected

When considering the data presented in Table 4, attention is drawn to the fact that the addition of Sel-Plex supplement to the horse diet affected the content of trace elements and heavy metals in milk. Thus, at the end of the experiment, the content of copper and cobalt in the milk of the mares of the experimental group decreased. In the middle of the experiment, when the selenium content increased by 35% (Table 3), copper and iron were not detected in the milk of the mares of the experimental group. Thus, selenium contributed to the neutralization of heavy metals in the body of animals.

To determine the effect of the Sel-Plex additive on the quality and content of vitamins in mare's milk, the vitamin composition was determined (Table 5).

**Table 5.** Vitamin composition of mare's milk.

Vitamin	Index	
	control	experience
A (retinol), µg/l	112.3	118.6
B1, µg/l	223.6	214.5
B2, µg/l	243.7	262.1
B12, µg/l	2.4	2.1
E, µg/l	720.2	717.6
C (ascorbic acid), mg/l	76.1	79.3

The content of vitamin A in the experimental sample exceeded the control sample by 5.06%, vitamin B2 by 7.55% and vitamin C by 4.2%. In terms of vitamin B1 content, the control sample exceeded the experimental sample by 4.24%, vitamin B12 by 14.28% and vitamin E by 0.36%. In general, the vitamin composition of mare's milk improved in a number of areas at the end of the experiment.

## 4 Conclusion

Based on the results of studies of the effect of Sel-Plex on the quality of mare's milk, we note the following:

- An increase in the mass fraction of protein in selenium-fortified milk led to an increase in the content of phosphorus and calcium. This suggests that selenium in organic form plays an active role in the absorption of these elements by animal organs. Milk obtained from such animals can be used as a raw material for the production of specialized

products for various population groups. Protein consumption in special populations (athletes) has a proven impact on body composition, recovery and muscle growth. They require large amounts of protein for optimal lean body mass gain during increased training loads and to maintain muscle mass during energy deficits.

- The introduction of Sel-Plex into the diet of mares increases the selenium content in milk. This has a beneficial effect on nutrition, including sports nutrition. With a lack of selenium in the body of athletes, the integrity of cell membranes is disrupted, the activity of enzymes in cell membranes is significantly reduced, calcium accumulates in cells, the metabolism of amino acids and ketone acids is disrupted, and energy-generating processes are reduced. After the introduction of selenium supplements into the diet of athletes, long-term beneficial changes in metabolic processes are noted. Consequently, products can be created based on milk fortified with selenium.
- The vitamin composition of mare's milk improves; in addition, the content of a number of heavy metals in it decreases. Food based on it becomes safer.

In conclusion, it should be noted that the use of the Sel-Plex additive, containing selenium in organic form, contributed to the improvement of the quality composition of mare's milk. It can be used as a raw material for the production of specialized products.

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