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Fermented mare milk product (Qymyz, Koumiss)

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ABSTRACT

Mare milk has been consumed for thousands of years in Central Asia and neighboring regions. Its composition is similar to human milk, but different from cow’s milk. Fermentation with lactic acid bacteria and yeasts leads to the production of a traditional drink called *qymyz*. *Qymyz*, which is a symbol of good health, is a central part of the national cuisine and of the traditional cycle of horse husbandry, as well as playing a role in the cultural identity of Central Asian people. Mare milk, along with *qymyz*, has been reported to have a wide range of therapeutic effects. In this article, the authors have compiled information on mare milk composition, *qymyz* production and the therapeutic effects of mare milk and its products.

Keywords: horse, mare milk, qymyz, koumiss, health

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1. Introduction

Despite the widespread use of cow's milk throughout the world, it is necessary to bear in mind the possibility of providing the population with milk from other farm animals. Of the 702.1 billion tons of milk produced globally, 118.7 (16.9%) billion tons are acquired from species other than dairy cattle. This proportion has been increasing regularly (B. Faye & Konuspayeva, 2012). Mare milk has been consumed for thousands of years in Central Asia and neighboring regions. Herodotus in the 5th century BC described how Scythians used to consume it (West, 1999). According to Outram et al. (2009) the first domestication of horses and consumption of mare milk took place in present day Akmola province of Kazakhstan approximately in 3500 BCE. Nowadays horses are mainly used as dairy animals in former USSR countries, such as Mongolia, and parts of China (Doreau & Boulot, 1989).

Due to its composition (proteins, lipids, vitamins, carbohydrates, macro and microelements, enzymes, hormones and a number of other important substances), raw horse milk has high nutritional value and digestibility. However, in Central Asian countries it is more widely consumed fermented under the name of *qymyz*. Fermented mare milk is phonetically pronounced as *qymyz*, but due to Russian domination in the region, the international literature term for fermented mare milk became better known as *koumiss* or *kumis*. It is an acidic and slightly alcoholic drink, the fermentation of which involves lactic bacteria and yeasts.

Many studies were carried out in 20th century in the USSR in Russian languages which are not accessible for the international community. This current review focuses mainly on data published by soviet authors which will help to understand the importance of mare milk and *qymyz* for human consumption.

2. Horse numbers, economic figures, market

According to the Food and Agriculture Organization of the United Nations (FAO), in 2017 there were about 60 million horses worldwide (Figure 2).

In most of the world except Central Asia, horses are not traditionally used as dairy animals. (Salimei & Park, 2017). In Kazakhstan horses are used as dairy animals and on top of that horse meat is consumed. About 30% of horses are slaughtered for meat annually in Kazakhstan and as a result, Kazakhstan has become the second largest horse meat producer in the world behind China (Bernard Faye, 2017). This has led to the steady growth in the number of horses in Kazakhstan. In fact, the number of horses has more than doubled since 2007 from 1.16 million to 2.85 million (Figure 3).

In Russia, on the other hand, a decrease of 15% (from 1.61 million to 1.37 million) between 2001-2014 was reported (Knyazev & Timchenko, 2016). However, in regions with developed horse meat production such as Yakutia, Bashkortstan, Altai, etc. the number of horses has increased by 22% between 2008-2010 (Kalashnikov & Kalashnikov, 2011). In Kyrgyzstan, an increase of 50% (from 347 thousand to 450 thousand) between 2006-2019 is reported. In Mongolia during the period 2009-2019 the number of horses increased from 2.2 million to 4.2 million. Uzbekistan has also seen an increase in horse numbers from 168 thousand to 242 thousand during the period 2008-2018. One of the other reasons for the steady increase in the number of horses is the low cost of horse breeding. Horses are bred in herds and feed on pasture during winter and summer, which means they do not rely on fodder.

3. Mare Milk

3.1. Differences and similarities with other types of animal milk

The comparison of the composition of mare milk with other types of milk cited by various references show important differences (Table 2). The reported values are relatively variable, which can be explained by different geographies, genetics and methods of analysis.

When comparing the content of sugar, protein and mineral salts, mare milk is quite similar to human milk but differs significantly from cow's milk

Milk protein from all animals is divided into two major groups: caseins (α_{s1} -, α_{s2} -, β -, κ - and γ -caseins) and whey proteins, which include α -lactalbumin, β -lactoglobulin, serum albumin, lactoferrin, immunoglobulins and lysozyme (Medhammar et al., 2012).

The protein in cow's milk is dominated by casein, which makes up about 72-77% of all nitrogen, while whey proteins account for only 13-18% of nitrogen, which is around 6 g/kg. This means cow's milk is defined as caseinic milk as it is rich in casein. Mare milk and human milk on the other hand are rich in whey protein containing 8.3 and 7 g/kg respectively, which is around 36 and 53% of all nitrogen respectively. Consecutively, mare milk and human milk are considered to be albumin-types of milk –high in albumin content (Malacarne et al., 2002; Uniacke-Lowe et al., 2010).

Mare milk casein mainly consists of β -casein (78.5%) while the α_s -caseins and κ -casein are present at 20% and 1.8%, respectively. Whey proteins in mare milk are present in the following proportions: β -lactoglobulin, 30.7%, α -lactalbumin, 28.5%, serum albumin-4.4%, immunoglobulins- 19.6%, lactoferrin – 7%, lysozyme 10.5% (Salimei & Fantuz, 2013). The percentages differ in other studies, for example Duisembaev (1989) reported that β -casein and κ -casein concentrations are similar and amount to 39.9 and 46.0% respectively, while that of α_s -casein is equal to 7.2%.

Non-protein nitrogen (NPN) include urea, free amino acids, amino sugars, bioactive peptides, uric acid, creatine, creatinine, nucleic acids, and nucleotide. Free amino acid content

of mare milk (1900 $\mu\text{m/kg}$) is higher than in cow's milk (560 $\mu\text{m/kg}$), but lower than in human milk (2930 $\mu\text{m/kg}$) (Salimei & Park, 2017).

Mare milk is poor in fat. In fact, according to Jennes (1988) mare milk, along with donkey milk, contains the least amount of fat among milk types regularly consumed by humans. As a result, horse milk has a lower calorific value (52 kcal/100g) than human (72 kcal/100g) or cow's (66 kcal/100g) milk. The lipids in milk are organized in globules, that have different sizes in different species. The lower the amount of fat in milk the smaller the diameter of the globules. Thus, mare milk has lipid globules with a small diameter. The diameter of mare milk globules ranges from 2-3 μm , while human and cow milk globules have an average diameter of 3-4 μm . (Gantner et al., 2015). Mare milk globules are similar to human milk globules in having branched oligosaccharide structures on the surface, which may enhance digestion by binding to lipases. Concerning lipid classes, mare milk is different from both human and cow's milk, in that it has 80% triglycerides, 9 – 10% free fatty acids and 5 – 19% phospholipids. Human and cow milk fat consists almost entirely of triglycerides (97-98%) (Malacarne et al., 2002; Miraglia & Martin-Rosset, 2006). In terms of free fatty acids mare milk, like human milk, has higher amounts of unsaturated fatty acids and a lower amount of saturated fatty acids compared to cow's milk (Claeys et al., 2014; Salimei & Fantuz, 2013; Sinyavskii, Yakunin, et al., 2016). From a dietetic point of view mare milk has an index of atherogenicity of 0.51 and thrombogenicity of 0.99, which are significantly lower than in cow's milk (2.87 and 3.53 respectively) (Sinyavskii, Yakunin, et al., 2016). The lower the atherogenic index the less likely lipids will adhere to cells of the immunological and circulatory system, and thus prevent atherosclerosis. The thrombogenicity index shows tendency to form clots in the blood vessels.

Carbohydrates in mare milk mainly consist of lactose and trace amounts of monosaccharides and oligosaccharides. Lactose content in mare milk (6-7g·100 ml⁻¹) is similar to that in human milk and significantly higher than in cow's milk (4-5g·100 ml⁻¹). Among

monosaccharides, glucose was reported to change during the lactation period and range between 50 -150 mg·L⁻¹ (Uniacke-Lowe & Fox, 2012). According to Seitov (2005) colostrum has a lower amount of carbohydrates than milk, which equals 2.9-3.4%. The amount increases rapidly and a day after foaling the amount equals 5%. The maximum amount of carbohydrates is present 1-3 months after foaling and ranges between 6.4-7%. Oligosaccharide concentration was reported to range between 79.8 - 217.8 mg·L⁻¹ and includes 58.3% neutral, 33.3% Neu5Ac, 6.25% fucosylated and 2.1% NeuGc oligosaccharides (Karav et al., 2018).

Minerals and trace elements play a major role in nutrition and aging of foals. Among major minerals (Ca, P, K, Na, Mg) Ca (0.83 g·kg⁻¹) and P (0.61 g·kg⁻¹) have the highest concentrations in mare milk, while Mg (0.06 g·kg⁻¹) has the lowest concentration (Park et al., 2017; Seitov et al., 2005). All five minerals have lower concentrations in human milk and higher concentrations in cow's milk (Salimei & Fantuz, 2013). Among trace elements (Zn, Fe, Cu) Zn has the highest concentration in any milk. Mare milk when compared to human and cow's milk has a lower concentration of Zn (0.02 mg·kg⁻¹). Fe and Cu have 0.01 and 0.005 mg/kg concentration in mare milk respectively (Medhammar et al., 2012). Similar concentrations of minerals were found in Mongolian mare milk (Ishii et al., 2014)

Data on vitamin content of mare milk is variable. Some authors note lower concentrations of fat-soluble vitamins in mare milk due to a low amount of milk fat (Salimei & Fantuz, 2013). Others report similar content in mare and cow milk (Fuquay et al., 2011). Both works agree on higher content of vitamin C in mare milk (150 mg·L⁻¹). The works of Berlin and Gricenko as reported by Seitov (2005) found concentrations of vitamins B₁ – 291-390; B₂ – 261-373; PP – 229; B₅- 1547; B₇ (biotin) -10.2; B₉ (folate) – 263; B₁₂ – 2,5-3.3 µg·L⁻¹ in mare milk.

3.2. Horse breed effect on mare milk composition

The effect of breed on milk composition is hard to differentiate from the effect of a certain feeding regimen or herd conditions. Additionally, individual variability of mares complicates the assessment. The stage of lactation plays a major role in the composition of mare milk. Authors note a higher content of fat, cholesterol, protein, total solids and citric acid, and a lower content of lactose and vitamin C in colostrum compared to milk (Coenen et al., 2011; Markiewicz-Kęszycka et al., 2015). Mare milking starts 20-45 days after foaling (Salimei & Park, 2017). The table below shows differences in milk composition and production between various breeds from post-Soviet countries.

Milk production in mares is even throughout the day, so most authors use the following formula proposed by Saigin to calculate daily milk production:

$$Us = (Uf * 24) / T$$

where Us - daily milk production (kg/day); Uf - amount of milk obtained during milking (kg); T - duration of milking.

According to Doreau and Boulot (1989) the yield of milk increases until the age of 11-15 years, but the age effect on milk composition is low. Milk yield differences according to breed is dependent on adult mare liveweight; 2.5 to 3.35 kg of milk per 100 kg of body weight (Salimei & Park, 2017). Duisembaev (1989) found that Kazakh zhabe type mares producing milk with a higher fat content produce less overall milk per day. Subsequently, milk productivity can be attributed to the characteristics of individual mares. According to reviews on the effect of nutrition of the mare, the energy supply of the diet above requirements has a negative effect on protein content in milk and the amount of milk produced can be increased by increasing the level of energy fed (Martuzzi & Doreau, 2006).

4. Qymyz

Qymyz is a traditional beverage of nomadic people in central Asia, which is obtained by fermenting mare's milk with lactic acid bacteria and yeasts. Mare milk undergoes two-step fermentation – lactic fermentation and alcoholic fermentation. The final products of these fermentations are lactic acid, ethyl alcohol, carbon dioxide and other by-products such as volatile acids, fusel alcohols, and other compounds with a strong and distinctive aroma and taste (Fuquay et al., 2011; Kondybayev et al., 2018). In 1858 N.V. Postnikov, a Russian doctor, discovered the effectiveness of the use of sour mare's milk in the treatment of patients with pulmonary tuberculosis and decided to introduce the use of *qymyz* into medical practice by opening a '*qymyz*' hospital near Samara, Russia. From this moment, hospitals became very popular and widespread in the USSR (Kudayarova et al., 2010).

There are two types of *qymyz*: i) traditional *qymyz*, which is prepared using starters containing unspecified microorganisms and ii) *qymyz* prepared with a mixture of pure cultures.

4.1. Traditional *qymyz*

In traditional processing, mare milk is inoculated using substances such as boiled millet, malt, soured cow's milk, soured soup, smoked horse meat, etc. Shigaeva and Ospanova (1983) described several types of traditional *qymyz* starters (Figure 4) and classified them into 3 main groups: a) spontaneous fermentation caused by microorganisms in fresh mare milk; b) fermentation caused by microorganisms from fermented milk products or sour dough; c) mixed combination of both types of starters. After inoculation mare milk is churned for 20-30 minutes and left to ferment at room temperature. During the day, fresh mare milk may be added several times depending on the number of milkings, which is around 6 milkings per day. The process

of churning and fermentation is repeated each time fresh mare milk is added. The purpose of adding milk and churning it is to increase *qymyz* volume and to increase acid and ethanol production, giving it a stronger taste.

Qymyz is churned in special containers called *saba* (made from horsehide) or *kubi* (made from wood). The purpose of churning is to spread the starter in the milk and to provide aeration for the yeasts. In times prior to the creation of the Soviet Union, leather containers for *qymyz* were very convenient for nomads, as they were attached in a special way to the saddle, and during a long trip, due to constant shaking from horse movement, *qymyz* acquired its true taste and strength. The wooden container, *Kubi*, has a cylindrical shape, tapering upwards, with a diameter of 20-40 cm and a height of about a meter, closed with a lid with a hole in the center. A plunger (a pole with a cross at the end or a disc with holes) is inserted into the hole and the *qymyz* is churned.

Microbiota of traditional *qymyz* are not well defined. The study of Bashkirian *qymyz* found bacteria, *A. aceti*, *L. bulgaricum* and *S. thermophilus* and yeasts, *Saccharomyces lactis* (previous name of *Kluyveromyces lactis*) and *Saccharomyces cartilaginosus*, along with yeast belonging to the genus *mycoderma* (Gricenko, 1964). A study conducted on *qymyz* from Mongolia found bacteria such as *L. helveticus*, *L. kefiranofaciens*, *L. lactis*, *L. mesenteroides* and yeasts, *Kluyveromyces marxianus*. Authors found that the most abundant bacteria in *qymyz* from Mongolia was *L. helveticus* and concluded that the final bacterial composition of *qymyz* is related to the high acid stress tolerance of lactobacilli (Miyamoto et al., 2010). Similarly in the Xin Jiang region of China the most abundant bacteria in *qymyz* was found to be *L. helveticus*, while *L. casei* and *L. plantarum* were prevalent in Inner Mongolia and the Qing Hai regions respectively (Sun et al., 2010). Yeast composition of *qymyz* in China showed the most dominant yeast species to be *K. marxianus*, *K. unispora* and *S. cerevisiae*, but their frequencies differed in different regions resulting in a distinct aroma and taste of *qymyz* belonging to these regions.

There was no study on correlation between yeast species and flavor of *qymyz* (Mu et al., 2012). In Kazakhstani *qymyz* bacteria such as *L. bulgaricus*, *L. casei*, *Str. lactis* and yeasts *Torulopsis kefyr* and *Torulopsis sphaerica* can be found (Shigaeva & Ospanova, 1983). According to Montanari et al. (1996), the most abundant yeast species in Kazakhstani *qymyz* is *Saccharomyces unisporus* (*Kazakhstania unispora*), which does not ferment lactose but can ferment galactose. Krekker (2001) confirmed that coculture of lactic acid bacteria (LAB) and yeasts naturally leads to domination of non-lactose fermenting yeast over other types of yeasts. This means that Kazakhstani *qymyz* has a 2-step fermentation where lactose is first hydrolyzed by LAB that metabolize glucose but secrete the remaining galactose to the environment where it is consumed by yeasts. Among LAB that have this type of metabolism are *L. bulgaricus*, *L. lactis*, *L. acidophilus* and *S. thermophiles* (Gadaga, 2001; Hickey et al., 1986).

4.2. *Qymyz making with pure cultures*

The first studies of *qymyz* production using pure cultures, carried out by Ginzburg and Bachinski-Raichenko (Seitov et al., 2005), date back to 1910. However, the guidelines to be followed for producing *qymyz* were defined and published in 1969 through Inter-Republican Technical Specifications (MRTU 46-573-69), which were approved by the Ministry of Agriculture and the Ministry of Meat and Dairy Industry of the USSR (Figure 5). According to this standard method there are 2 steps in the preparation of *qymyz*. First the laboratory starter is prepared with a mixed culture of *L. bulgaricus* and *Saccharomyces lactis*, which ferment lactose and have antibacterial properties (Figure 6). According to the standard, mare milk didn't have to be pasteurized, but it had to have acidity $\leq 0.06\%$ w/v lactic acid, a density of 1,029-1,033 g/cm³ and fat content of at least 1% w/v. Second, the bulk starter is prepared on the basis of the obtained laboratory starter over four to five days at 26-28 °C. *Qymyz* is obtained by using a

bulk starter and adding fresh mare milk 2-3 times a day until it loses its activity. An indicator of good activity is the formation of bubbles (foam) when churned, detection of at least 8-10 yeast cells and abundance of LAB in the field of view of a microscope (Seitov et al., 2005; Shigaeva & Ospanova, 1983).

In present times, most *qymyz* hospitals use *qymyz* from the previous year as a starter. The scheme of *qymyz* production in hospitals can be seen from Figure 7 (Mursalimov & Satyev, 1989; O. N. Popova, 1996). There is a possibility that due to the standardization of *qymyz* production in the USSR all hospitals had to use MRTU 46-573-69 in their production, but later on hospitals started using old *qymyz* as a starter.

4.3. *Qymyz* quality

Three categories of *qymyz* obtained from pure culture were defined according to their sensory quality in National standard of the Republic of Kazakhstan - ST RK 1004-98 (Kazakh Research and Development Institute of Meat and Dairy Industry of the Ministry of Agriculture of the Republic of Kazakhstan., 1999): weak – one day fermentation, medium – two-day fermentation, and strong – three-day fermentation (Table 4).

A study conducted on people's preferences of *qymyz* resulted in the following sensory characteristics being ranked from 'liked most' to 'liked least': taste, freshness, acidity, color, smell. The results show that aroma of *qymyz* is the least significant for consumers. The same study showed that a higher proportion of consumers preferred strong *qymyz* (30%) when compared to weak (12%) and medium (5%) *qymyz*. 54% of responders couldn't perceive the different *qymyz* types (Real, 2019).

The content of *qymyz* protein or fat remained relatively the same as in the mare milk used for the preparation, but amino acid composition changed: the essential amino acids, lysine,

valine, isoleucine, phenylalanine and tyrosine decreased; methionine, cysteine and leucine didn't change, but tryptophan increased; the nonessential amino acids, histidine, aspartic acid, glutamic acid and proline increased; alanine, serine and arginine decreased (Lebedev, 1963; Urbisinov, 1992). According to Damdinsurengiin (2000) concentrations of all amino acids decreased, except for threonine and alanine. Gafiatullin (2006) reported an overall 11% decrease in protein; subsequently casein and whey concentrations also decreased by 11.2% and 10.7%. Weak *qymyz* usually still contains a high amount of lactose and as a result has a slightly sweet taste. Overall *qymyz* has a sour taste and slightly spicy flavor, without any extraneous flavors or odors. A yeasty flavor is acceptable in *qymyz*. The consistency of *qymyz* is liquid, homogeneous, carbonated, slightly foaming, without any particles of fat.

4.4. *Qymyz process modifications*

Most of the studies on controlled preparation of *qymyz* proposed methods similar to the MRTU 46-573-69 standard but with a number of changes; i) pasteurization of mare milk, ii) fermentation with different or additional species of microorganisms, iii) preparation of *qymyz* with cow's milk, iv) extending storage of mare milk and *qymyz* using different methods. Mare milk pasteurization has been a topic of a number of studies. In general heating mare milk above 65 °C precipitates milk whey protein and albumin, oxidizes polyunsaturated fatty acids and vitamin C, and changes the taste of the milk. Due to these reasons and the relative resistance of horses to such diseases as brucellosis and tuberculosis, the use of unpasteurized mare milk for *qymyz* production is assumed to be safe (Rahimov et al., 2018; Seitov et al., 2005). Pasteurization of mare milk would be essential when it comes to producing *qymyz* made from pure strains, because unpasteurized mare's milk can contain a variety of microorganisms (Skorodumova, 1961). Shigaeva and Ospanova (1983) proposed the pasteurization of mare

milk at 65°C for 15 min and reported no difference in taste, color or consistency. Authors reported a slower fermentation rate in pasteurized milk as the utilization of lactose and the production of ethanol reached maximal rates after 7-14 days, while in unpasteurized milk 3-5 days was enough to get the same results. Kanareikina and Kanareikin (2017) compared time-temperature combinations for pasteurization ranging from 63-94°C and found that 30-min pasteurization at temperatures of 63, 65 and 67 °C resulted in the same color and consistency, while the taste and aroma was close to raw mare milk.

The use of different strains of microorganisms in starter conditions improves not just the taste and aroma of *qymyz*, but also its shelf-life and probiotic properties. The main difficulty during *qymyz* making is the control of the kinetics of acidification. Generally, in *qymyz* hospitals the maximum tolerated level of acidity of *qymyz* is reached in 72 hours. Beyond this, *qymyz* is considered unsuitable for consumption, which has the consequence of limiting the shelf-life of the *qymyz*. The use of selected microbial strains capable of producing less lactic acid and a slower fermentation rate appeared to be a means of extending the shelf-life of *qymyz* as shown by (Shigaeva & Ospanova, 1983) with strains of *S. lactis* and *Lb. bulgaricus* which led to the maximum formation of lactic acid of 1% and 2.25% respectively.

Yeasts in *qymyz* have been shown to grow better in more acidic environments (pH 4-5) (Hrisanova, 1966). Indeed separate coculture of *Torulopsis kefir* var *kumis* with *S. lactis* and *Lb. bulgaricus* leads to better growth with *Lb. bulgaricus*, that has a higher production of lactic acid (Shigaeva & Ospanova, 1983). In contrast, yeast such as *Saccharomyces lactis* has an optimum pH for lactose hydrolysis at 6.5 (Guy & Bingham, 1978). According to Fox et al. (2015), usage of LAB with lactose-fermenting yeast is optimal in *qymyz* fermentation as lactic acid formation and alcoholic fermentations occur simultaneously and the products of fermentation are in definite proportions. However simultaneous fermentation leads to

competition between LAB and lactose-fermenting yeasts and results in a lower number of yeasts and thus a lower amount of ethanol (Krekker, 2001).

Several authors have used acetate forming bacteria such as *Acetobacter aceti* (Gricenko, 1964; Shigaeva & Ospanova, 1983; Urbisinov, 1992). The features of *A. aceti* include uptake of lactic acid and ethanol. Gricenko (1964) reported production of vitamin B₁₂ by *A. aceti*. Shigaeva and Ospanova (1983) reported production of diacetyl, that gives dairy products a buttery flavor, by *A. aceti*. In their work, addition of *A. aceti* to the usual starter consisting of LAB and yeasts leads to a decrease in ethanol concentration and an increase in lactic acid concentration in the final composition of *qymyz*. Thus, they concluded that in the mixture of LAB and ethanol producing yeasts, *A. aceti* prefers to consume ethanol rather than lactic acid and overall recommended the inclusion of *A. aceti* in starters as the aromatic quality of *qymyz* increased. However, a decrease in ethanol could be due to the inhibition of yeast growth as Gricenko (1964) reported a slower growth rate of lactose fermenting yeast and the total suppression of yeast that don't ferment lactose in the presence of *A. aceti*. Overall interaction between microorganisms in *qymyz* is summarized in Figure 8. In general bacteria are responsible for production of acids, while yeast is responsible for ethanol production. Acids lower the pH, which has a positive effect on yeast growth. LAB and lactose (+) yeasts compete for lactose, which has a negative effect on growth of lactose (+) yeasts. Lactose (-) yeasts grow on galactose produced by LAB. Acetic acid bacteria (AAB) inhibit growth of lactose (+) yeast and suppress growth of lactose (-) yeasts, and thus inhibit production of ethanol in *qymyz*. Aroma is mostly produced by yeasts and AAB.

The cost and availability of mare milk made authors seek ways to prepare *qymyz* from cow's milk. Hrisanova (1966) simply decreased pH of cow's milk to 5.2 and added *qymyz* starter cultures. The resulting cow milk *qymyz* had the same antagonistic effect against *M. tuberculosis* (H37Rv strain) as *qymyz* from mare milk. Shamgin et al. (1977) proposed using a

mixture of whole milk (33-36%), skimmed milk (0.6-1%) and whey (63-67%), which results in 1:1 ratio of casein to whey, similar to mare milk. Küçükçetin et al. (2003) used ultrafiltration, microfiltration and nanofiltration to modify cow's milk so that the final composition was equal to mare milk in terms of protein, lactose and other compositional factors. Prepared *qymyz* had no significant compositional or sensorial difference from mare milk *qymyz*.

Extending mare milk storage is mainly done by spray drying. Before drying, mare milk is thickened in a vacuum. Reconstituted milk had a lower amount of vitamins C and A, 5-6% less protein, lactose and fat (Mursalimov & Satyev, 1989). *Qymyz* lyophilization and reconstitution after 12 months leads to a lower amount of lactic acid (0.06% decrease), and ethanol almost evaporates completely. Bacterial and yeast populations remain viable (Musaeva, 1996). Damdinsurengiin (2000) was able to prolong shelf life of *qymyz* to 21 days at 20 °C by adding stabilizers, agar-agar (E406) and apple pectin (E440) and pasteurizing bottled *qymyz* at 95 °C for 5-10 minutes.

5. Different products from mare milk

In Europe mare milk is gaining interest in France, Germany and Italy as a source of nutrition and as a substitute for children allergic to cow's milk (Malacarne et al., 2002). In Kazakhstan, in addition to *qymyz*, several other types of products such as yogurt and curd are made for children (Sinyavskii, Torgautov, et al., 2016; Yakunin et al., 2017). Iannella (2015) developed a method of cheese making from mare milk using camel chymosin at 0.4 g to 5 L. Before addition of chymosin authors advocated adding starter cultures as they suppress undesirable bacteria, and produce lactic acid, which increase curd firmness and lower pH to 5.1 (optimal for camel chymosin). Mare milk has also been used in cosmetics such as shampoo, shower gel, body cream, soap, hand cream (Stuparu et al., 2016). However, the main use of

horses in Europe remains to be recreational riding and horse racing (Liljenstolpe, 2009). In Central Asia, mare milk is generally used to produce *qymyz*, but it is also served fresh in special “saumal” (fresh mare milk) sanatoriums.

6. Health benefits of mare milk and *qymyz*

Qymyz is accepted as a therapeutic drink in the former USSR countries mainly against tuberculosis. Its anti-tuberculosis effect was reported in 1861 by a military doctor N. Zeland (Kudayarova et al., 2010). *Qymyz* is believed to inhibit growth of bad bacteria due to low pH, bactericidal substances produced by *qymyz* microbiota and high levels of lysozyme and lactoferrin in the original mare milk. Gricenko (1964) found that lactose- negative yeast isolated from *qymyz* had a higher bactericidal effect than lactose positive yeasts against non-pathogenic *B. subtilis* and *B. mesentericus*. Hrisanova (1966) reported that the antibacterial effect of *qymyz* was due to *qymyz* microbiota as *qymyz* prepared from cow’s milk showed the same antibacterial effect against *M. tuberculosis* (H₃₆Rv strain) as *qymyz* from mare milk.

Mare milk and *qymyz* are beneficial against atherosclerosis (Chiofalo et al., 2006). Zhang et al. (2012) have found that a strain isolated from *qymyz* reduces high cholesterol. Chen et al. (2010) report *qymyz* to be rich in angiotensin I-converting enzyme (ACE) inhibitors, which indicates the beneficial effect of *qymyz* on cardiovascular health.

Jirillo et al. (2010) found that mare milk strengthens the immune system. It was explained by a high content of albumin and globulin in the milk, which are building materials for antibodies (Stuparu et al., 2016).

Mare milk is beneficial for children with cow milk protein allergy (CPMA). As a result, in European countries such as France, Germany, Belgium and Italy mare milk is sold as an alternative to powdered milk formula for babies (Pieszka et al., 2016). Low lactose in *qymyz* is

beneficial for lactose intolerant people. 88% of Mongolians are lactose intolerant, but they can still consume *qymyz* without any problem (Fox et al., 2015).

Mare milk was found to have anti-proliferative and anti-tumor effects against lung cancer cells (Mao et al., 2009). Consequently authors have recommended use of mare milk in treatment of cancer, as along with its anti-tumor effects, *qymyz* can be beneficial in fighting chemotherapy side effects (Stuparu et al., 2016; Uniacke-Lowe et al., 2010).

Other than tuberculosis, diseases such as asthma, hyperlipidemia, anemia, nephritis, diarrhea, and gastritis, as well as other digestive diseases, are treated with *qymyz* and mare milk (Hou et al., 2019; Salimei & Park, 2017).

7. Conclusion

Mare milk and *qymyz* have been the topic of a vast number of studies since the beginning of the 20th century. Mare milk composition is closer to human milk than cow's. Its composition varies due to horse breed, feed, location and lactation period. *Qymyz* is the main product made from mare milk. The microbiota of *qymyz* is highly variable, but the main microorganisms in *qymyz* are LAB and yeasts. Mare milk, along with *qymyz*, has long been used in the treatment of various diseases. Recent studies are reporting new beneficial properties of mare milk and *qymyz*. Due to these findings *qymyz* production has a lot of market potential. The quality of *qymyz* depends on the use of specific microorganisms and specific fermentation conditions. The interaction between these microorganisms is one of the more complex and important areas of *qymyz* production, which requires further research. Optimizing succession (non-lactose fermentation yeast) or co-fermentation (lactose-fermenting yeast) of lactic and ethanol fermentations in *qymyz* is still unclear, and thus deserves further study.

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References

- Agriculture—Official statistics—Statistics of Kyrgyzstan*. (2020, September 29).
<http://stat.kg/ru/statistics/selskoe-hozyajstvo/>
- Akhatova, I. A. (2008). *Horse breeding at the turn of the century*. Gilem.
- Chen, Y., Wang, Z., Chen, X., Liu, Y., Zhang, H., & Sun, T. (2010). Identification of angiotensin I-converting enzyme inhibitory peptides from koumiss, a traditional fermented mare's milk. *Journal of Dairy Science*, 93(3), 884–892. <https://doi.org/10.3168/jds.2009-2672>
- Chiofalo, B., Drogoul, C., & Salimei, E. (2006). Other utilisation of mare's and ass's milk. *Nutrition and Feeding of the Broodmare*, 120, 133–147.
- Claeys, W. L., Verraes, C., Cardoen, S., De Block, J., Huyghebaert, A., Raes, K., Dewettinck, K., & Herman, L. (2014). Consumption of raw or heated milk from different species: An evaluation of the nutritional and potential health benefits. *Food Control*, 42, 188–201. <https://doi.org/10.1016/j.foodcont.2014.01.045>
- Coenen, M., Kienzle, E., Vervuert, I., & Zeyner, A. (2011). Recent German Developments in the Formulation of Energy and Nutrient Requirements in Horses and the Resulting Feeding Recommendations. *Journal of Equine Veterinary Science*, 31(5–6), 219–229. <https://doi.org/10.1016/j.jevs.2011.03.204>
- Committee on statistics*. (2020, September 29). <https://stat.gov.kz/>

479 Damdinsurengiin, N. (2000). *The influence of food builders on biochemical changes in the protein*
 480 *complex of koumiss during storage* [Autoreferat of dissertation for the degree of candidate of
 481 technical sciences].

482 Doreau, M., & Boulot, S. (1989). Recent knowledge on mare milk production: A review. *Livestock*
 483 *Production Science*, 22(3–4), 213–235. [https://doi.org/10.1016/0301-6226\(89\)90057-2](https://doi.org/10.1016/0301-6226(89)90057-2)

484 Duisembaev, K. I. (1989). *Zoo-technical bases of intensification of manufacture of mare's milk on*
 485 *koumiss farms*: [Autoreferat of dissertation for the degree of doctor of agricultural sciences].

486 FAOSTAT. (2020, September 29). <http://www.fao.org/faostat/en/#data/QA>

487 Faye, B., & Konuspayeva, G. (2012). The sustainability challenge to the dairy sector – The growing
 488 importance of non-cattle milk production worldwide. *International Dairy Journal*, 24(2), 50–
 489 56. <https://doi.org/10.1016/j.idairyj.2011.12.011>

490 Faye, Bernard. (2017). *Report of a foreign expert in the direction of horse breeding*.

491 Fox, P. F., Uniacke-Lowe, T., McSweeney, P. L. H., & O'Mahony, J. A. (2015). *Dairy Chemistry and*
 492 *Biochemistry*. Springer International Publishing. <https://doi.org/10.1007/978-3-319-14892-2>

493 Fuquay, J. W., Fox, P. F., & McSweeney, P. L. H. (Eds.). (2011). *Encyclopedia of dairy sciences*. Elsevier.

494 Gadaga, T. (2001). Growth characteristics of *Candida kefyr* and two strains of *Lactococcus lactis*
 495 subsp. *Lactis* isolated from Zimbabwean naturally fermented milk. *International Journal of*
 496 *Food Microbiology*, 70(1–2), 11–19. [https://doi.org/10.1016/S0168-1605\(01\)00501-3](https://doi.org/10.1016/S0168-1605(01)00501-3)

497 Gafiatullin, F. I. (2006). *Genetic and parathypical variability of protein composition of milk in mares of*
 498 *heavy breeds* [Autoreferat of dissertation for the degree of candidate of biological sciences].

499 Gantner, V., Mijić, P., Baban, M., Škrtić, Z., & Turalija, A. (2015). The overall and fat composition of
 500 milk of various species. *Mljekarstvo*, 223–231.
 501 <https://doi.org/10.15567/mljekarstvo.2015.0401>

502 Gladkova, E. E. (1990). *Improving the technology of milk production and breeding foals on koumiss*
 503 *farm in conditions of stable keeping horses* [Autoreferat of dissertation for the degree of
 504 candidate of agricultural sciences].

505 Gricenko, T. T. (1964). *The influence of microflora on the content of vitamins of group "B" in koumiss*
 506 [Autoreferat of dissertation for the degree of candidate of biological sciences].

507 Guy, E. J., & Bingham, E. W. (1978). Properties of β -Galactosidase of *Saccharomyces Lactis* in Milk and
 508 Milk Products. *Journal of Dairy Science*, 61(2), 147–151. [https://doi.org/10.3168/jds.S0022-](https://doi.org/10.3168/jds.S0022-0302(78)83570-X)
 509 0302(78)83570-X

510 Hickey, M. W., Hillier, A. J., & Jago, G. R. (1986). Transport and Metabolism of Lactose, Glucose, and
 511 Galactose in Homofermentative Lactobacilli. *Applied and Environmental Microbiology*, 51(4),
 512 825–831. <https://doi.org/10.1128/AEM.51.4.825-831.1986>

513 Hou, Q., Li, C., Liu, Y., Li, W., Chen, Y., Siqinbateer, Bao, Y., saqila, W., Zhang, H., Menghe, B., & Sun, Z.
 514 (2019). Koumiss consumption modulates gut microbiota, increases plasma high density
 515 cholesterol, decreases immunoglobulin G and albumin. *Journal of Functional Foods*, 52, 469–
 516 478. <https://doi.org/10.1016/j.jff.2018.11.023>

517 Hrisanova, L. P. (1966). *Scientific bases of koumiss production on pure cultures* [Autoreferat of
 518 dissertation for the degree of candidate in biological sciences].

519 Iannella, G. (2015). Equid milk renneting through pure camel chymosin and cheese manufacturing.
 520 *Direct Research Journal of Agriculture and Food Science*, 3(9), 167–172.

521 Imangaliev, A. I. (1967). *Productive qualities of adaev horses*: [Autoreferat of dissertation for the
 522 degree of candidate of agricultural sciences].

523 Ishii, S., Hosino, B., Komiyama, H., Uehara, A., & Nurtazin, S. (2014). Study on Production and
 524 Properties of Kumiss of Herders in Mongolian Dry Steppe. *Journal of Arid Land Studies*, 24(1),
 525 3.

526 Jenness, R. (1988). Composition of Milk. In N. P. Wong, R. Jenness, M. Keeney, & E. H. Marth (Eds.),
 527 *Fundamentals of Dairy Chemistry* (pp. 1–38). Springer US. [https://doi.org/10.1007/978-1-](https://doi.org/10.1007/978-1-4615-7050-9_1)
 528 4615-7050-9_1

529 Jirillo, E., D'Alessandro, A. G., Amati, L., Tafaro, A., Jirillo, F., Pugliese, V., & Martemucci, G. (2010).
530 Modulation of the human aged immune response by donkey milk intake. *61st Annual*
531 *Meeting of the European Association for Animal Production*, 45.

532 Kalashnikov, R. V., & Kalashnikov, V. V. (2011). The development of herd horse breeding in Russia.
533 *Achievements of Science and Technology of Agribusiness*, 9, Article 9.
534 <https://cyberleninka.ru/article/n/razvitie-tabunnogo-konevodstva-v-rossii>

535 Kanareikina, S. G., & Kanareikin, V. I. (2017). Effect of pasteurization regimes on organoleptic
536 performance and acidity of mare's milk during storage. *Izvestija Orenburgskogo*
537 *Gosudarstvennogo Agrarnogo Universiteta*, 1 (63), 144–147.

538 Karav, S., Salcedo, J., Frese, S. A., & Barile, D. (2018). Thoroughbred mare's milk exhibits a unique and
539 diverse free oligosaccharide profile. *FEBS Open Bio*, 8(8), 1219–1229.
540 <https://doi.org/10.1002/2211-5463.12460>

541 Kazakh Research and Development Institute of Meat and Dairy Industry of the Ministry of Agriculture
542 of the Republic of Kazakhstan. (1999). *ST RK 1004-98: Natural koumiss. Specifications*
543 [National standard of the Republic of Kazakhstan].

544 Knyazev, S. P., & Timchenko, A. M. (2016). Dynamics of Horse Stock And Current State of Horse
545 Resources in Siberia. *Vestnik Novosibirskogo Gosudarstvennogo Agrarnogo Universiteta*,
546 1 (38), 139–145.

547 Kondybayev, A., Zhakupbekova, A., Amutova, F., Omarova, A., Nurseitova, M., Akhmetsadykova, S.,
548 Akhmetsadykov, N., Konuspayeva, G., & Faye, B. (2018). Volatile organic compounds profiles
549 in milk fermented by lactic bacteria. *International Journal of Biology and Chemistry*, 11, 57–
550 67. <https://doi.org/10.26577/ijbch-2018-2-345>

551 Krekker, L. G. (2001). *Development of the technology of bacterial concentrate for the production of*
552 *koumiss* [Autoreferat of dissertation for the degree of candidate of technical sciences].

553 Kücükçetin, A., Yaygin, H., Hinrichs, J., & Kulozik, U. (2003). Adaptation of bovine milk towards mares'
 554 milk composition by means of membrane technology for koumiss manufacture. *International*
 555 *Dairy Journal*, 13(12), 945–951. [https://doi.org/10.1016/S0958-6946\(03\)00143-2](https://doi.org/10.1016/S0958-6946(03)00143-2)

556 Kudayarova, R. R., Gilmutdinova, L. T., Yamaletdinov, K. S., Gilmutdinov, A. R., Gabdelhakova, L. T., &
 557 Zinnatullin, R. H. (2010). Historical aspects of the use of koumiss in medicine. *Siberian*
 558 *Medicine Bulletin*, 9(5), 186–189.

559 Lebedev, A. F. (1963). *Some questions of the development of kumys production in a non-steppe zone*
 560 [Autoreferat of dissertation for the degree of candidate of agricultural sciences].

561 Liljenstolpe, C. (2009). Horses in Europe. *EU Equus*, 32.

562 Malacarne, M., Martuzzi, F., Summer, A., & Mariani, P. (2002). Protein and fat composition of mare's
 563 milk: Some nutritional remarks with reference to human and cow's milk. *International Dairy*
 564 *Journal*, 12(11), 869–877. [https://doi.org/10.1016/S0958-6946\(02\)00120-6](https://doi.org/10.1016/S0958-6946(02)00120-6)

565 Mao, X., Gu, J., Sun, Y., Xu, S., Zhang, X., Yang, H., & Ren, F. (2009). Anti-proliferative and anti-tumour
 566 effect of active components in donkey milk on A549 human lung cancer cells. *International*
 567 *Dairy Journal*, 19(11), 703–708. <https://doi.org/10.1016/j.idairyj.2009.05.007>

568 Markiewicz-Kęszycka, M., Czyżak-Runowska, G., Wójtowski, J., Jóźwik, A., Pankiewicz, R., Łęska, B.,
 569 Krzyżewski, J., Strzałkowska, N., Marchewka, J., & Bagnicka, E. (2015). Influence of stage of
 570 lactation and year season on composition of mares' colostrum and milk and method and
 571 time of storage on vitamin C content in mares' milk: Influence of stage of lactation and
 572 season on composition of mares' colostrum and milk. *Journal of the Science of Food and*
 573 *Agriculture*, 95(11), 2279–2286. <https://doi.org/10.1002/jsfa.6947>

574 Martuzzi, F., & Doreau, M. (2006). Mare milk composition: Recent findings about protein fractions
 575 and mineral content. In *Nutrition and feeding of the broodmare*.

576 Medhammar, E., Wijesinha-Bettoni, R., Stadlmayr, B., Nilsson, E., Charrondiere, U. R., & Burlingame,
 577 B. (2012). Composition of milk from minor dairy animals and buffalo breeds: A biodiversity

perspective. *Journal of the Science of Food and Agriculture*, 92(3), 445–474.
<https://doi.org/10.1002/jsfa.4690>

Miraglia, N., & Martin-Rosset, W. (2006). *Nutrition and feeding of the broodmare*. Academic Publishers.

Miyamoto, M., Seto, Y., Nakajima, H., Burenjargal, S., Gombojav, A., Demberel, S., & Miyamoto, T. (2010). Denaturing Gradient Gel Electrophoresis Analysis of Lactic Acid Bacteria and Yeasts in Traditional Mongolian Fermented Milk. *Food Science and Technology Research*, 16(4), 319–326. <https://doi.org/10.3136/fstr.16.319>

Mongolian statistical information service-Livestock. (2020, September 29). Mongolian Statistical Information Service. https://1212.mn/Stat.aspx?LIST_ID=976_L10_1

Montanari, G., Zambonelli, C., Grazia, L., Kamesheva, G. K., & Shigaeva, M. Kh. (1996). *Saccharomyces unisporus* as the principal alcoholic fermentation microorganism of traditional koumiss. *Journal of Dairy Research*, 63(02), 327. <https://doi.org/10.1017/S0022029900031836>

Mu, Z., Yang, X., & Yuan, H. (2012). Detection and identification of wild yeast in Koumiss. *Food Microbiology*, 31(2), 301–308. <https://doi.org/10.1016/j.fm.2012.04.004>

Mursalimov, V. S., & Satyev, B. H. (1989). *Bashkir horse*. Bashk. kn. izd-vo.

Musaeva, A. M. (1996). *Characterization of freeze-dried mare's milk koumiss* [Autoreferat of dissertation for the degree of candidate of biological sciences].

Nurushev, M. Z., Ershatov, K. B., Bizhanova, G. K., Nurusheva, G. M., & Stepachev, V. V. (2008). Biochemical features of colostrum and milk of Adaev mares and their use. *Proceedings of the Orenburg State Agrarian University*, 3(19–1), Article 19–1. <https://cyberleninka.ru/article/n/biohimicheskie-osobennosti-moloziva-i-moloka-adaevskih-kobyl-i-ih-ispolzovanie>

Outram, A. K., Stear, N. A., Bendrey, R., Olsen, S., Kasparov, A., Zaibert, V., Thorpe, N., & Evershed, R. P. (2009). The Earliest Horse Harnessing and Milking. *Science*, 323(5919), 1332–1335. <https://doi.org/10.1126/science.1168594>

604 Park, Y. W., Haenlein, G. F. W., & Wendorff, W. L. (2017). *Handbook of milk of non-bovine mammals*.
 605 John Wiley & Sons Ltd; CABDirect.
 606 <https://onlinelibrary.wiley.com/doi/book/10.1002/9781119110316>

607 Pavlova, A. I. (2004). *Dairy productivity of mares of the yakut breed and technology of production of*
 608 *frozen mare milk* [Autoreferat of dissertation for the degree of candidate of agricultural
 609 sciences].

610 Pieszka, M., Łuszczyński, J., Zamachowska, M., Augustyn, R., Długosz, B., & Hędrzak, M. (2016). Is
 611 mare milk an appropriate food for people? – A review. *Annals of Animal Science*, 16(1), 33–
 612 51. <https://doi.org/10.1515/aoas-2015-0041>

613 Popova, L. A., & Gromova, T. V. (2014). Koumiss production as a promising direction in the
 614 development of agritourism in Altai. *Bulletin of Altai State Agrarian University*, 2 (112),
 615 Article 2 (112). [https://cyberleninka.ru/article/n/proizvodstvo-kumysa-kak-perspektivnoe-](https://cyberleninka.ru/article/n/proizvodstvo-kumysa-kak-perspektivnoe-napravlenie-v-razvitii-agroturizma-na-altae)
 616 [napravlenie-v-razvitii-agroturizma-na-altae](https://cyberleninka.ru/article/n/proizvodstvo-kumysa-kak-perspektivnoe-napravlenie-v-razvitii-agroturizma-na-altae)

617 Popova, O. N. (1996). *Economic and biological features of horses of Belarusian breed* [Autoreferat of
 618 dissertation for the degree of candidate of agricultural sciences].

619 Rahimov, A. H., Vagapova, O. A., & Sirazetdinova, E. I. (2018). Features of production of kumys by
 620 different ways from milk of mares. *Molodezh' I Nauka*, 2, 110.

621 Real, S. (2019). *Narratives of kumis consumption and production in contemporary Kazakhstan* [Thesis,
 622 Nazarbayev University School of Sciences and Humanities].
 623 <https://nur.nu.edu.kz/handle/123456789/4012>

624 Salimei, E., & Fantuz, F. (2013). Horse and Donkey Milk. In *Milk and Dairy Products in Human*
 625 *Nutrition* (pp. 594–613). John Wiley & Sons. <https://doi.org/10.1002/9781118534168.ch27>

626 Salimei, E., & Park, Y. W. (2017). Mare milk. In *Handbook of milk of non-bovine mammals*.

627 Seitov, Z. S., Duisembaev, K. I., & Khasenov, A. N. (2005). *Kumys. Shubat* (3rd ed.) [Текст]. Daur.

628 Shamgin, V. K., Zalashko, L. S., Mochalova, K. V., & Pastuhova, Z. M. (1977). *Dairy product for the*
629 *production of fermented milk drink koumiss and method for producing this product* (USSR
630 Patent No. SU 546334 A1). <https://www.elibrary.ru/item.asp?id=39805842>

631 Shigaeva, M. Kh., & Ospanova, M. Sh. (1983). *Microflora of national fermented milk drinks.*
632 <http://elib.kaznu.kz/book/9564>

633 Sinyavskii, Yu. A., Torgautov, A. S., & Yakunin, A. V. (2016). Prospects for designing baby food and diet
634 food based on mare's milk. *Evrasiiskii Soyuz Uchenykh*, 2-3 (23), Article 2- 3 (23).
635 [https://cyberleninka.ru/article/n/perspektivy-konstruirovaniya-produktov-detskogo-i-](https://cyberleninka.ru/article/n/perspektivy-konstruirovaniya-produktov-detskogo-i-dieticheskogo-pitaniya-na-osnove-kobyliego-moloka)
636 [dieticheskogo-pitaniya-na-osnove-kobyliego-moloka](https://cyberleninka.ru/article/n/perspektivy-konstruirovaniya-produktov-detskogo-i-dieticheskogo-pitaniya-na-osnove-kobyliego-moloka)

637 Sinyavskii, Yu. A., Yakunin, A. V., Torgautov, A. S., & Berdigaliev, A. B. (2016). Comparative
638 assessment of fatty acid composition, indices of atherogenicity and thrombogenicity of milk
639 of various types of farm animals. *Problemy Sovremennoi Nauki i Obrazovaniya*, 7 (49), Article
640 7 (49). [https://cyberleninka.ru/article/n/sravnitel'naya-otsenka-zhironokislotnogo-sostava-](https://cyberleninka.ru/article/n/sravnitel'naya-otsenka-zhironokislotnogo-sostava-indeksov-aterogennosti-i-trombogennosti-moloka-razlichnyh-vidov-selskohozyaystvennyh)
641 [indeksov-aterogennosti-i-trombogennosti-moloka-razlichnyh-vidov-selskohozyaystvennyh](https://cyberleninka.ru/article/n/sravnitel'naya-otsenka-zhironokislotnogo-sostava-indeksov-aterogennosti-i-trombogennosti-moloka-razlichnyh-vidov-selskohozyaystvennyh)

642 Skorodumova, A. M. (1961). *Dietary and therapeutic dairy products*. (2nd ed.). Medgiz.
643 http://alcddata.narod.ru/Skorodumova_1961/index.html

644 Stuparu, A. A., Oroian, T., & Strugariu, C. E. (2016). Pharmaceuticals and Dietary Supplements
645 Extracted from Mare's Milk. *Bulletin of University of Agricultural Sciences and Veterinary*
646 *Medicine Cluj-Napoca. Animal Science and Biotechnologies*, 73(1).
647 <https://doi.org/10.15835/buasvmcn-asb:11429>

648 Sun, Z., Liu, W., Zhang, J., Yu, J., Zhang, W., Cai, C., Menghe, B., Sun, T., & Zhang, H. (2010).
649 Identification and characterization of the dominant lactobacilli isolated from koumiss in
650 China. *The Journal of General and Applied Microbiology*, 56(3), 257–265.
651 <https://doi.org/10.2323/jgam.56.257>

652 Timerbulatova, A. T. (2015). *Milk productivity of Bashkir breed mares and the quality of koumiss*
653 *when feeding the probiotic feed additive "Biogumitel"* [Autoreferat of dissertation for the
654 degree of candidate of agricultural sciences].

655 Uniacke-Lowe, T., & Fox, P. F. (2012). Equid Milk: Chemistry, Biochemistry and Processing. In B. K.
656 Simpson (Ed.), *Food Biochemistry and Food Processing* (pp. 491–530). Wiley-Blackwell.
657 <https://doi.org/10.1002/9781118308035.ch26>

658 Uniacke-Lowe, T., Huppertz, T., & Fox, P. F. (2010). Equine milk proteins: Chemistry, structure and
659 nutritional significance. *International Dairy Journal*, 20(9), 609–629.
660 <https://doi.org/10.1016/j.idairyj.2010.02.007>

661 Urbisinov, Zh. K. (1992). *Nutritional and biological value of traditionally local dairy and meat products*
662 [Autoreferat of dissertation for the degree of candidate in biological sciences].

663 West, S. (1999). Introducing the Scythians: Herodotus on Koumiss (4.2). *Museum Helveticum*, 56(2),
664 76–86. JSTOR.

665 Yakunin, A. V., Sinyavskii, Yu. A., & Ibraimov, Y. S. (2017). Evaluation of the nutritional value of mare's
666 milk and fermented milk products based on it and the possibility of their use in baby food.
667 *Voprosy Sovremennoi Pediatrii*, 16(3), Article 3. [https://cyberleninka.ru/article/n/otsenka-](https://cyberleninka.ru/article/n/otsenka-pischevoy-tsennosti-kobyliego-moloka-i-kislomolochnyh-produktov-na-ego-osnove-i-vozmozhnosti-ih-ispolzovaniya-v-detskom-pitanii)
668 [pischevoy-tsennosti-kobyliego-moloka-i-kislomolochnyh-produktov-na-ego-osnove-i-](https://cyberleninka.ru/article/n/otsenka-pischevoy-tsennosti-kobyliego-moloka-i-kislomolochnyh-produktov-na-ego-osnove-i-vozmozhnosti-ih-ispolzovaniya-v-detskom-pitanii)
669 [vozmozhnosti-ih-ispolzovaniya-v-detskom-pitanii](https://cyberleninka.ru/article/n/otsenka-pischevoy-tsennosti-kobyliego-moloka-i-kislomolochnyh-produktov-na-ego-osnove-i-vozmozhnosti-ih-ispolzovaniya-v-detskom-pitanii)

670 Zeinullin, A. S. (1992). *Milk productivity of horses of the Kushum breed and ways to increase it in the*
671 *Ural region* [Autoreferat of dissertation for the degree of candidate of agricultural sciences].

672 Zhang, Y., Du, R. T., He, Q. W., & Li, H. (2012). Effect of Lactobacillus casei Zhang administration on
673 liver lipids metabolism of high-Fat diet induced hypercholesterolemia rats. *Sci. Agric. Sin*, 45,
674 943–950.

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Figure legends

Fig. 1. Countries where horses are used as dairy animals (Doreau & Boulot, 1989)

Fig. 2. Horse population worldwide (FAOSTAT, 2019)

Fig. 3. Horse population growth in Kazakhstan between 2005-2019 (stat.gov.kz, 2019)

Fig. 4. Traditional *qymyz* starters (Shigaeva & Ospanova, 1983).

Fig. 5. *Qymyz* preparation containers: (A) different forms of saba; (B) kubi.

Fig. 6. *Qymyz* starter preparation scheme according to MRTU 46-573-69 (Seitov et al., 2005; Shigaeva & Ospanova, 1983): (A) preparation of laboratory starter; (B) preparation of bulk starter.

Fig. 7. Starter preparation (A) and *qymyz* production (B) in ‘*qymyz*’ hospitals (Mursalimov & Satyev, 1989; O. N. Popova, 1996).

Fig. 8. Diagram of interaction between microorganisms in *qymyz*. Green lines - stimulation, promotion; yellow- competition, inhibition; red - suppression. Dotted lines – overall relationship between microorganisms.

Table 1

Horse population in Central Asian and bordering countries.

Country	Horse population	Year reported	References
Kazakhstan	2.85 million	2019	(Committee on Statistics, 2020)
Kyrgyzstan	0.52 million	2019	(Agriculture - Official Statistics - Statistics of Kyrgyzstan, 2020)
Mongolia	4.21 million	2019	(Mongolian Statistical Information Service-Livestock, 2020)
Russia	1.37 million	2014	(Knyazev & Timchenko, 2016)
Uzbekistan	0.24 million	2018	(FAOSTAT, 2020)

Table 2.

Mare, cow and human milk composition (% W/V)

References	Mare milk	Cow milk	Human milk
Protein			
(Park et al., 2017)	2	3,3	1,3
(Claeys et al., 2014)	1,4-3,2	3-3,9	0,9-1,9
(Akhatova, 2008)	1,6-2,3	2,5-3,3	1,8-3,5
(Jenness, 1988)	2,5	3,2	0,9
Fat			
(Park et al., 2017)	1,2	3,8	4,2
(Claeys et al., 2014)	0,3-4,2	3,3-5,4	2,1-4
(Akhatova, 2008)	1,2-2,8	3,7	3,7
(Jenness, 1988)	1,9	3,9	4,5
Carbohydrate			
(Park et al., 2017)	6,5	4,8	7
(Claeys et al., 2014)	5,6-7,2	4,4-5,6	6,3-7
(Akhatova, 2008)	6,2-7	4,7	6,3
(Jenness, 1988)	6,2	4,6	7,1

Table 3

Protein composition of mare, human and cow milk in g/kg. In brackets % of total nitrogen.

	Mare			%			Human		%		Cow			%		
References	(Uniac ke- Lowe et al., 2010)	(Malaca rne et al., 2002)	(Gafiatul lin, 2006)	(Uniac ke- Lowe et al., 2010)	(Malaca rne et al., 2002)	(Gafiatul lin, 2006)	(Uniac ke- Lowe et al., 2010)	(Malaca rne et al., 2002)	(Uniac ke- Lowe et al., 2010)	(Malaca rne et al., 2002)	(Uniac ke- Lowe et al., 2010)	(Malaca rne et al., 2002)	(Gafiatul lin, 2006)	(Uniac ke- Lowe et al., 2010)	(Malaca rne et al., 2002)	(Gafiatul lin, 2006)
Whole protein	24	21	20	100	100	100	12	14	100	100	34	33	33	100	100	100
Whey protein	8,3	8,3	11,7	34,2	38,8	54,7	6,2	7,6	53,0	53,5	6,3	5,7	6,6	18,4	17,5	20,4
Casein	13,6	10,7	8,0	56,0	50,0	37,4	2,4	3,7	20,5	26,1	26,0	25,1	25,9	76,0	77,2	79,4
Non- protein nitrogen *	2,4	2,4	-	9,9	11,2	-	3,1	2,9	26,5	20,4	1,9	1,7	-	5,6	5,2	-
6.38																

Table 4.

Milk composition and productivity of different horse breeds

Horse breed	Protein (%)	Dry matter (%)	Lactose (%)	Fat (%)	Milk production (kg/day)	Average liveweight (kg)	Author
Adai	2.12	10.2	6.48	1.62	10,2	376-430	(Imangaliev, 1967; Nurushev et al., 2008)
Bashkir	2,06-2,25	10,2-10,7	5,8-6,2	1,3-1,8	8,8	370-420	(Timerbulatova, 2015)
Kazakh zhabe type	2,03-2,09	-	6,24-6,33	1,5-1,58	9,5	475-529	(Duisembaev, 1989)
Kirgiz	2,1	-	6,9	1,8	12,9	-	(L. A. Popova & Gromova, 2014)
Kushum type	1,7	-	-	1,4	7,7-11,3	495-570	(Zeinullin, 1992)
Russian heavy draft	1,84-1,96	9,65-10,2	6,35	1,46-1,74	14,1	496	(Gladkova, 1990)
Soviet heavy draft	1,81-2,16	9,67-9,9	6,35	1,6	16,5	702	(Gladkova, 1990)
Yakut	2,27	10,5	8,46	0,93	8,8-13,3	-	(Pavlova, 2004)

Table 5Major microorganisms in *qymyz* from different regions

<i>Qymyz</i> regions	Bacteria	Yeast	References
Bashkortostan	<i>A. aceti</i> , <i>L. bulgaricum</i> , <i>S. thermophilus</i>	<i>Kluyveromyces lactis</i> <i>Saccharomyces</i> <i>cartilaginosus</i> Mycoderma yeasts	(Gricenko, 1964)
China	<i>L. helveticus</i> <i>L. casei</i> <i>L. plantarum</i>	<i>Kluyveromyces marxianus</i> <i>Kazakhstania unispora</i> <i>Saccharomyces cerevisiae</i>	(Mu et al., 2012; Sun et al., 2010)
Kazakhstan	<i>L. bulgaricus</i> , <i>L. casei</i> , <i>Str. lactis</i>	<i>Torulopsis kefir</i> <i>Torulopsis sphaerica</i> <i>Kazakhstania unispora</i>	(Montanari et al., 1996; Shigaeva & Ospanova, 1983)
Mongolia	<i>L. helveticus</i> , <i>L. kefiranoformis</i> , <i>L. lactis</i> , <i>L. mesenteroides</i>	<i>Kluyveromyces marxianus</i>	(Miyamoto et al., 2010)

Table 6

Qymyz sensory types classification according to ST RK 1004-98 (Kazakh Research and Development Institute of Meat and Dairy Industry of the Ministry of Agriculture of the Republic of Kazakhstan., 1999).

Characteristics	Types of <i>qymyz</i>		
	Weak	Medium	Strong
Lactic acid %	0.7	0.9	1.08
Ethanol %	1	1.5	3
Density g/cm ³	1.025-1.021	1.020-1.018	1.017-1.015



Figure 1

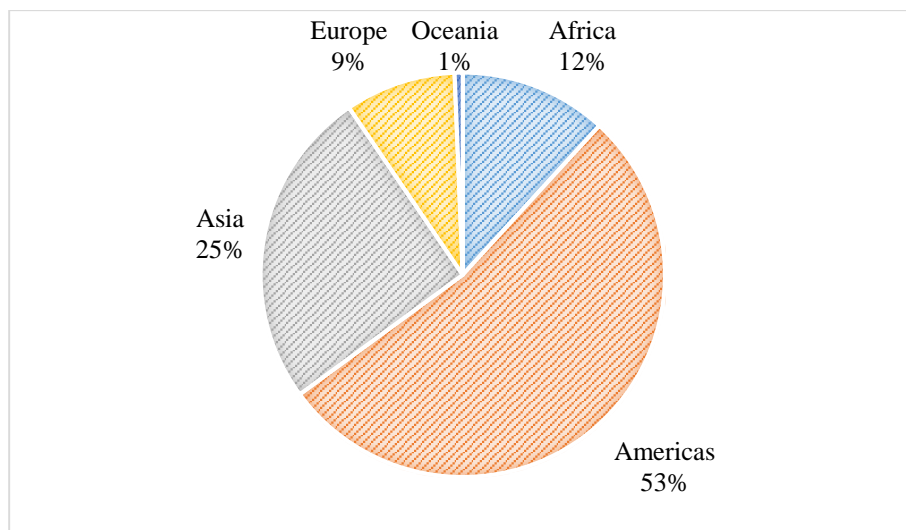


Figure 2

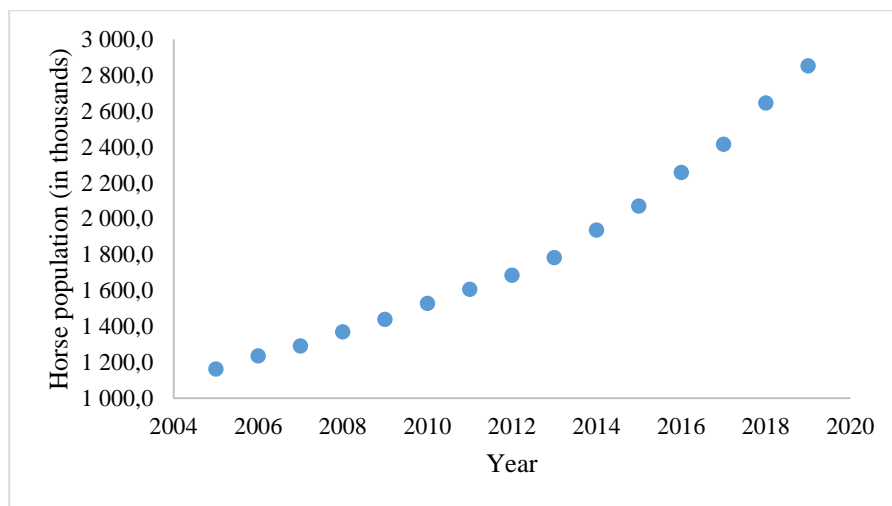


Figure 3

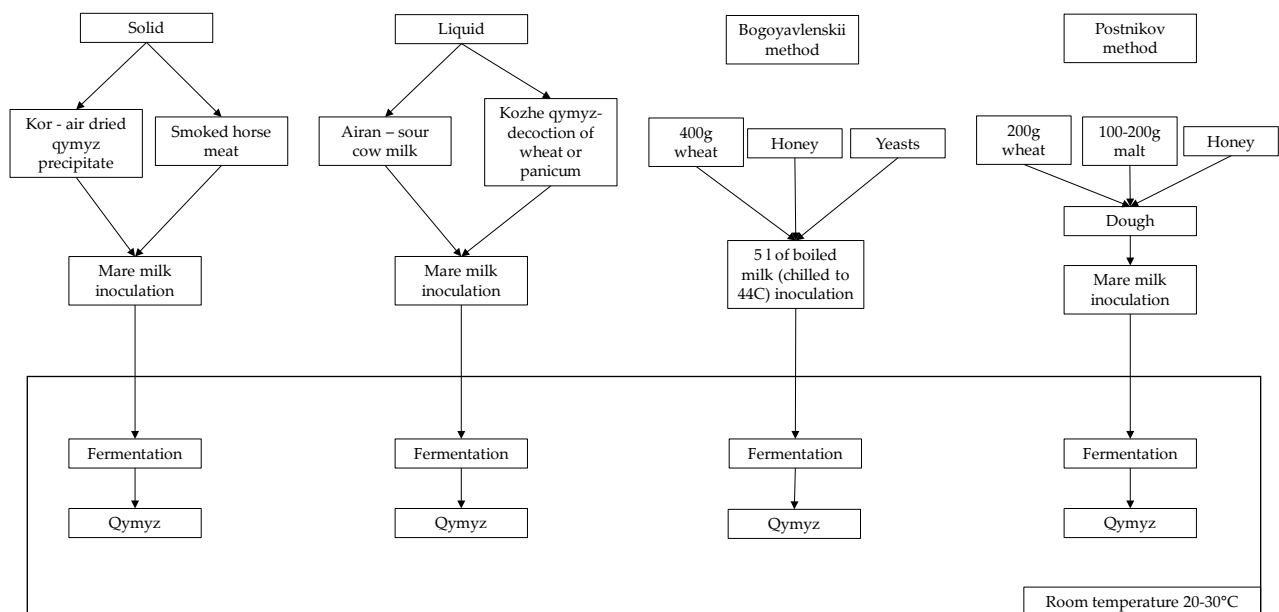
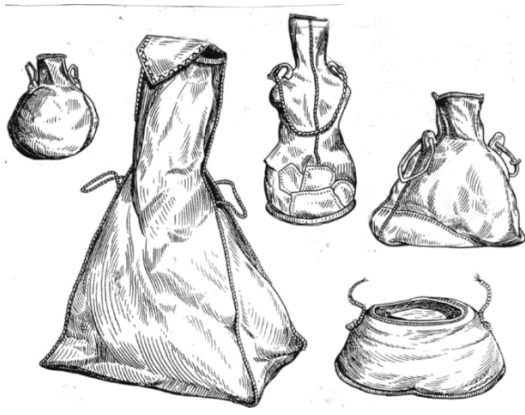


Figure 4



A



B

Figure 5

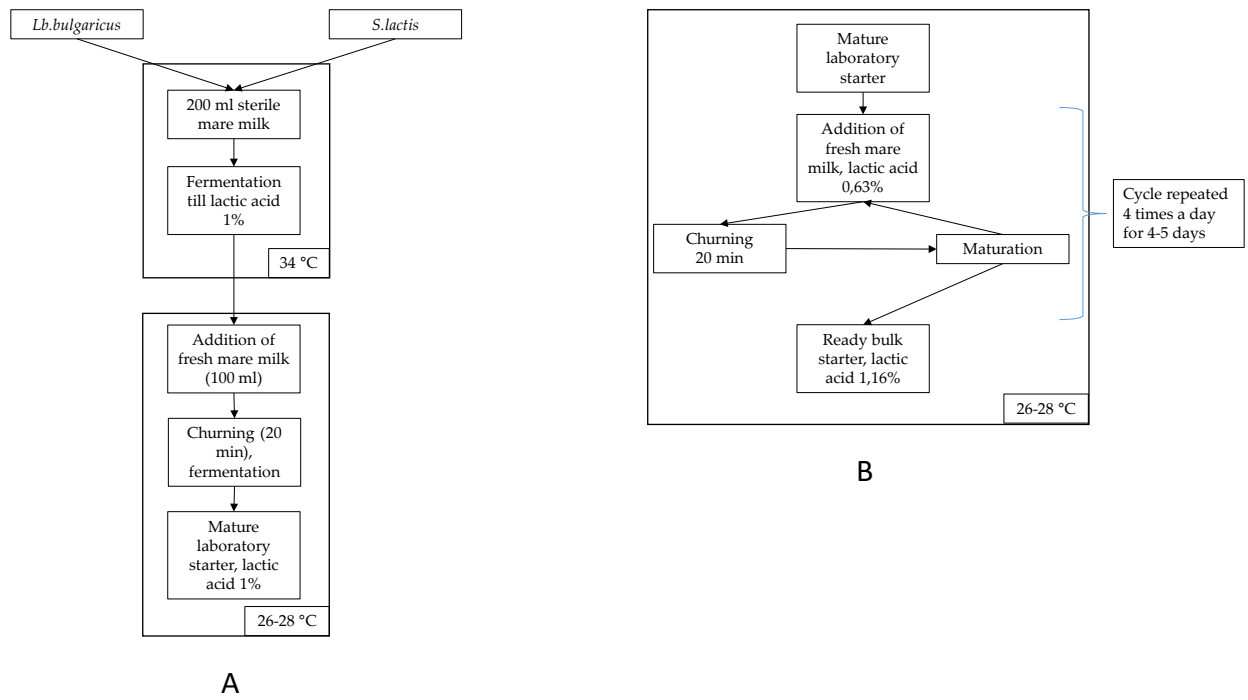


Figure 6

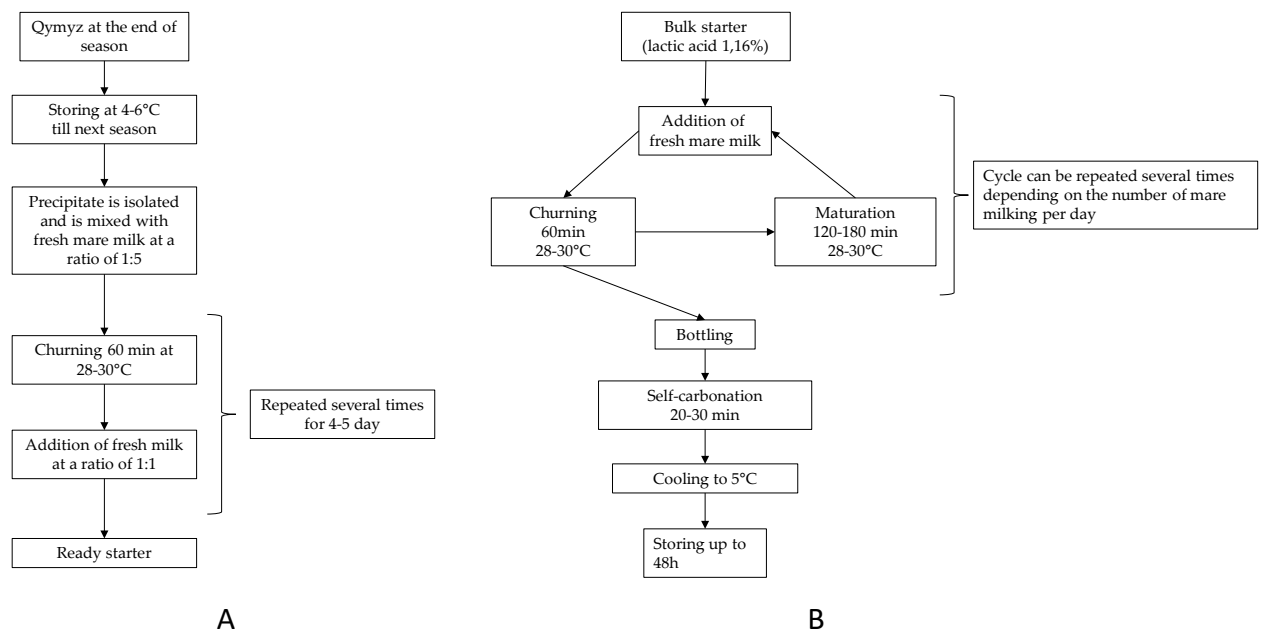


Figure 7

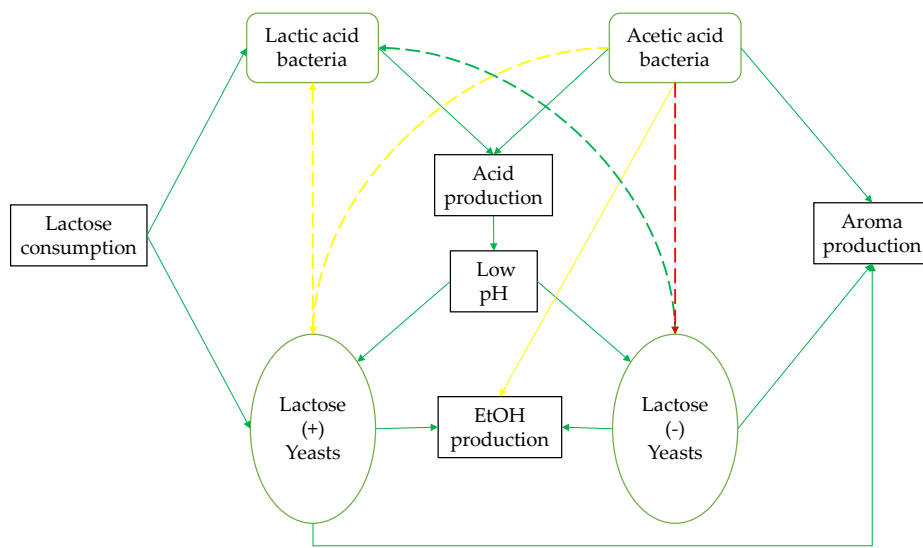


Figure 8