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1 **Fermented mare milk product (Qymyz, Koumiss)**

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24 **ABSTRACT**

25

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

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

35

36

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58 **1. Introduction**

59

60 Despite the widespread use of cow's milk throughout the world, it is necessary to bear
61 in mind the possibility of providing the population with milk from other farm animals. Of the
62 702.1 billion tons of milk produced globally, 118.7 (16.9%) billion tons are acquired from
63 species other than dairy cattle. This proportion has been increasing regularly (B. Faye &
64 Konuspayeva, 2012). Mare milk has been consumed for thousands of years in Central Asia and
65 neighboring regions. Herodotus in the 5th century BC described how Scythians used to
66 consume it (West, 1999). According to Outram et al. (2009) the first domestication of horses
67 and consumption of mare milk took place in present day Akmola province of Kazakhstan
68 approximately in 3500 BCE. Nowadays horses are mainly used as dairy animals in former
69 USSR countries, such as Mongolia, and parts of China (Doreau & Boulot, 1989).

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

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

81

82 **2. Horse numbers, economic figures, market**

83

84 According to the Food and Agriculture Organization of the United nations (FAO), in
85 2017 there were about 60 million horses worldwide (Figure 2).

86 In most of the world except Central Asia, horses are not traditionally used as dairy
87 animals. (Salimei & Park, 2017). In Kazakhstan horses are used as dairy animals and on top of
88 that horse meat is consumed. About 30% of horses are slaughtered for meat annually in
89 Kazakhstan and as a result, Kazakhstan has become the second largest horse meat producer in
90 the world behind China (Bernard Faye, 2017). This has led to the steady growth in the number
91 of horses in Kazakhstan. In fact, the number of horses has more than doubled since 2007 from
92 1.16 million to 2.85 million (Figure 3).

93 In Russia, on the other hand, a decrease of 15% (from 1.61 million to 1.37 million)
94 between 2001-2014 was reported (Knyazev & Timchenko, 2016). However, in regions with
95 developed horse meat production such as Yakutia, Bashkortstan, Altai, etc. the number of
96 horses has increased by 22% between 2008-2010 (Kalashnikov & Kalashnikov, 2011). In
97 Kyrgyzstan, an increase of 50% (from 347 thousand to 450 thousand) between 2006-2019 is
98 reported. In Mongolia during the period 2009-2019 the number of horses increased from 2,2
99 million to 4,2 million. Uzbekistan has also seen an increase in horse numbers from 168 thousand
100 to 242 thousand during the period 2008-2018. One of the other reasons for the steady increase
101 in the number of horses is the low cost of horse breeding. Horses are bred in herds and feed on
102 pasture during winter and summer, which means they do not rely on fodder.

103

104 **3. Mare Milk**

105

106 *3.1. Differences and similarities with other types of animal milk*

107

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

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

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

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

123 Mare milk casein mainly consists of β -casein (78.5%) while the α_s -caseins and κ -casein
124 are present at 20% and 1.8%, respectively. Whey proteins in mare milk are present in the
125 following proportions: β -lactoglobulin, 30.7%, α -lactalbumin, 28.5%, serum albumin-4.4%,
126 immunoglobulins- 19.6%, lactoferrin – 7%, lysozyme 10,5% (Salimei & Fantuz, 2013). The
127 percentages differ in other studies, for example Duisembaev (1989) reported that β -casein and
128 κ -casein concentrations are similar and amount to 39.9 and 46.0% respectively, while that of
129 α_s -casein is equal to 7.2%.

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

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

134 Mare milk is poor in fat. In fact, according to Jennes (1988) mare milk, along with
135 donkey milk, contains the least amount of fat among milk types regularly consumed by humans.
136 As a result, horse milk has a lower calorific value (52 kcal/100g) than human (72 kcal/100g) or
137 cow's (66 kcal/100g) milk. The lipids in milk are organized in globules, that have different
138 sizes in different species. The lower the amount of fat in milk the smaller the diameter of the
139 globules. Thus, mare milk has lipid globules with a small diameter. The diameter of mare milk
140 globules ranges from 2-3 μm , while human and cow milk globules have an average diameter of
141 3-4 μm . (Gantner et al., 2015). Mare milk globules are similar to human milk globules in having
142 branched oligosaccharide structures on the surface, which may enhance digestion by binding to
143 lipases. Concerning lipid classes, mare milk is different from both human and cow's milk, in
144 that it has 80% triglycerides, 9 – 10% free fatty acids and 5 – 19% phospholipids. Human and
145 cow milk fat consists almost entirely of triglycerides (97-98%) (Malacarne et al., 2002; Miraglia
146 & Martin-Rosset, 2006). In terms of free fatty acids mare milk, like human milk, has higher
147 amounts of unsaturated fatty acids and a lower amount of saturated fatty acids compared to
148 cow's milk (Claeys et al., 2014; Salimei & Fantuz, 2013; Sinyavskii, Yakunin, et al., 2016).
149 From a dietetic point of view mare milk has an index of atherogenicity of 0.51 and
150 thrombogenicity of 0.99, which are significantly lower than in cow's milk (2.87 and 3.53
151 respectively) (Sinyavskii, Yakunin, et al., 2016). The lower the atherogenic index the less likely
152 lipids will adhere to cells of the immunological and circulatory system, and thus prevent
153 atherosclerosis. The thrombogenicity index shows tendency to form clots in the blood vessels.

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

157 monosaccharides, glucose was reported to change during the lactation period and range between
158 50 -150 mg·L⁻¹ (Uniacke-Lowe & Fox, 2012). According to Seitov (2005) colostrum has a
159 lower amount of carbohydrates than milk, which equals 2.9-3.4%. The amount increases
160 rapidly and a day after foaling the amount equals 5%. The maximum amount of carbohydrates
161 is present 1-3 months after foaling and ranges between 6.4-7%. Oligosaccharide concentration
162 was reported to range between 79.8 - 217.8 mg·L⁻¹ and includes 58.3% neutral, 33.3% Neu5Ac,
163 6.25% fucosylated and 2.1% NeuGc oligosaccharides (Karav et al., 2018).

164 Minerals and trace elements play a major role in nutrition and aging of foals. Among
165 major minerals (Ca, P, K, Na, Mg) Ca (0.83 g·kg⁻¹) and P (0.61 g·kg⁻¹) have the highest
166 concentrations in mare milk, while Mg (0.06 g·kg⁻¹) has the lowest concentration (Park et al.,
167 2017; Seitov et al., 2005). All five minerals have lower concentrations in human milk and higher
168 concentrations in cow's milk (Salimei & Fantuz, 2013). Among trace elements (Zn, Fe, Cu)
169 Zn has the highest concentration in any milk. Mare milk when compared to human and cow's
170 milk has a lower concentration of Zn (0.02 mg·kg⁻¹). Fe and Cu have 0.01 and 0.005 mg/kg
171 concentration in mare milk respectively (Medhammar et al., 2012). Similar concentrations of
172 minerals were found in Mongolian mare milk (Ishii et al., 2014)

173 Data on vitamin content of mare milk is variable. Some authors note lower
174 concentrations of fat-soluble vitamins in mare milk due to a low amount of milk fat (Salimei &
175 Fantuz, 2013). Others report similar content in mare and cow milk (Fuquay et al., 2011). Both
176 works agree on higher content of vitamin C in mare milk (150 mg·L⁻¹). The works of Berlin
177 and Gricenko as reported by Seitov (2005) found concentrations of vitamins B₁ – 291-390; B₂
178 – 261-373; PP – 229; B₅- 1547; B₇ (biotin) -10.2; B₉ (folate) – 263; B₁₂ – 2,5-3.3 µg·L⁻¹ in mare
179 milk.

180

181 *3.2. Horse breed effect on mare milk composition*

182

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

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

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

193

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

196 According to Doreau and Boulot (1989) the yield of milk increases until the age of 11-
197 15 years, but the age effect on milk composition is low. Milk yield differences according to
198 breed is dependent on adult mare liveweight; 2.5 to 3.35 kg of milk per 100 kg of body weight
199 (Salimei & Park, 2017). Duisembaev (1989) found that Kazakh zhabe type mares producing
200 milk with a higher fat content produce less overall milk per day. Subsequently, milk
201 productivity can be attributed to the characteristics of individual mares. According to reviews
202 on the effect of nutrition of the mare , the energy supply of the diet above requirements has a
203 negative effect on protein content in milk and the amount of milk produced can be increased by
204 increasing the level of energy fed (Martuzzi & Doreau, 2006).

205

206 4. Qymyz

207

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

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

220

221 4.1. Traditional *qymyz*

222

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

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

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

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

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

267

268 4.2. *Qymyz making with pure cultures*

269

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

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

285 In present times, most *qymyz* hospitals use *qymyz* from the previous year as a starter.
286 The scheme of *qymyz* production in hospitals can be seen from Figure 7 (Mursalimov & Satyev,
287 1989; O. N. Popova, 1996). There is a possibility that due to the standardization of *qymyz*
288 production in the USSR all hospitals had to use MRTU 46-573-69 in their production, but later
289 on hospitals started using old *qymyz* as a starter.

290

291 4.3. *Qymyz* quality

292

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

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

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

306 valine, isoleucine, phenylalanine and tyrosine decreased; methionine, cysteine and leucine
307 didn't change, but tryptophan increased; the nonessential amino acids, histidine, aspartic acid,
308 glutamic acid and proline increased; alanine, serine and arginine decreased (Lebedev, 1963;
309 Urbisinov, 1992). According to Damdinsurengiin (2000) concentrations of all amino acids
310 decreased, except for threonine and alanine. Gafiatullin (2006) reported an overall 11%
311 decrease in protein; subsequently casein and whey concentrations also decreased by 11.2% and
312 10.7%. Weak *qymyz* usually still contains a high amount of lactose and as a result has a slightly
313 sweet taste. Overall *qymyz* has a sour taste and slightly spicy flavor, without any extraneous
314 flavors or odors. A yeasty flavor is acceptable in *qymyz*. The consistency of *qymyz* is liquid,
315 homogeneous, carbonated, slightly foaming, without any particles of fat.

316

317 *4.4. Qymyz process modifications*

318

319 Most of the studies on controlled preparation of *qymyz* proposed methods similar to the
320 MRTU 46-573-69 standard but with a number of changes; i) pasteurization of mare milk, ii)
321 fermentation with different or additional species of microorganisms, iii) preparation of *qymyz*
322 with cow's milk, iv) extending storage of mare milk and *qymyz* using different methods. Mare
323 milk pasteurization has been a topic of a number of studies. In general heating mare milk above
324 65 °C precipitates milk whey protein and albumin, oxidizes polyunsaturated fatty acids and
325 vitamin C, and changes the taste of the milk. Due to these reasons and the relative resistance of
326 horses to such diseases as brucellosis and tuberculosis, the use of unpasteurized mare milk for
327 *qymyz* production is assumed to be safe (Rahimov et al., 2018; Seitov et al., 2005).
328 Pasteurization of mare milk would be essential when it comes to producing *qymyz* made from
329 pure strains, because unpasteurized mare's milk can contain a variety of microorganisms
330 (Skorodumova, 1961). Shigaeva and Ospanova (1983) proposed the pasteurization of mare

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

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

347 Yeasts in *qymyz* have been shown to grow better in more acidic environments (pH 4-5)
348 (Hrisanova, 1966). Indeed separate coculture of *Torulopsis kefir* var *kumis* with *S. lactis* and
349 *Lb. bulgaricus* leads to better growth with *Lb. bulgaricus*, that has a higher production of lactic
350 acid (Shigaeva & Ospanova, 1983). In contrast, yeast such as *Saccharomyces lactis* has an
351 optimum pH for lactose hydrolysis at 6.5 (Guy & Bingham, 1978). According to Fox et al.
352 (2015), usage of LAB with lactose-fermenting yeast is optimal in *qymyz* fermentation as lactic
353 acid formation and alcoholic fermentations occur simultaneously and the products of
354 fermentation are in definite proportions. However simultaneous fermentation leads to

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

357 Several authors have used acetate forming bacteria such as *Acetobacter aceti* (Gricenko,
358 1964; Shigaeva & Ospanova, 1983; Urbisinov, 1992). The features of *A. aceti* include uptake
359 of lactic acid and ethanol. Gricenko (1964) reported production of vitamin B₁₂ by *A.aceti*.
360 Shigaeva and Ospanova (1983) reported production of diacetyl, that gives dairy products a
361 buttery flavor, by *A. aceti*. In their work, addition of *A. aceti* to the usual starter consisting of
362 LAB and yeasts leads to a decrease in ethanol concentration and an increase in lactic acid
363 concentration in the final composition of *qymyz*. Thus, they concluded that in the mixture of
364 LAB and ethanol producing yeasts, *A. aceti* prefers to consume ethanol rather than lactic acid
365 and overall recommended the inclusion of *A. aceti* in starters as the aromatic quality of *qymyz*
366 increased. However, a decrease in ethanol could be due to the inhibition of yeast growth as
367 Gricenko (1964) reported a slower growth rate of lactose fermenting yeast and the total
368 suppression of yeast that don't ferment lactose in the presence of *A. aceti*. Overall interaction
369 between microorganisms in *qymyz* is summarized in Figure 8. In general bacteria are
370 responsible for production of acids, while yeast is responsible for ethanol production. Acids
371 lower the pH, which has a positive effect on yeast growth. LAB and lactose (+) yeasts compete
372 for lactose, which has a negative effect on growth of lactose (+) yeasts. Lactose (-) yeasts grow
373 on galactose produced by LAB. Acetic acid bacteria (AAB) inhibit growth of lactose (+) yeast
374 and suppress growth of lactose (-) yeasts, and thus inhibit production of ethanol in *qymyz*.
375 Aroma is mostly produced by yeasts and AAB.

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

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

385 Extending mare milk storage is mainly done by spray drying. Before drying, mare milk
386 is thickened in a vacuum. Reconstituted milk had a lower amount of vitamins C and A, 5-6%
387 less protein, lactose and fat (Mursalimov & Satyev, 1989). *Qymyz* lyophilization and
388 reconstitution after 12 months leads to a lower amount of lactic acid (0.06% decrease), and
389 ethanol almost evaporates completely. Bacterial and yeast populations remain viable (Musaeva,
390 1996). Damdinsurengiin (2000) was able to prolong shelf life of *qymyz* to 21 days at 20 °C by
391 adding stabilizers, agar-agar (E406) and apple pectin (E440) and pasteurizing bottled *qymyz* at
392 95 °C for 5-10 minutes.

393

394 **5. Different products from mare milk**

395

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

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

408

409 **6. Health benefits of mare milk and *qymyz***

410

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

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

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

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

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

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

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

439

440 **7. Conclusion**

441

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

454

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456

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460 **References**

461

462 *Agriculture—Official statistics—Statistics of Kyrgyzstan*. (2020, September 29).

463 <http://stat.kg/ru/statistics/selskoe-hozyajstvo/>

464 Akhatova, I. A. (2008). *Horse breeding at the turn of the century*. Gilem.

465 Chen, Y., Wang, Z., Chen, X., Liu, Y., Zhang, H., & Sun, T. (2010). Identification of angiotensin I-

466 converting enzyme inhibitory peptides from koumiss, a traditional fermented mare's milk.

467 *Journal of Dairy Science*, 93(3), 884–892. <https://doi.org/10.3168/jds.2009-2672>

468 Chiofalo, B., Drogoul, C., & Salimei, E. (2006). Other utilisation of mare's and ass's milk. *Nutrition and*

469 *Feeding of the Broodmare*, 120, 133–147.

470 Claeys, W. L., Verraes, C., Cardoen, S., De Block, J., Huyghebaert, A., Raes, K., Dewettinck, K., &

471 Herman, L. (2014). Consumption of raw or heated milk from different species: An evaluation

472 of the nutritional and potential health benefits. *Food Control*, 42, 188–201.

473 <https://doi.org/10.1016/j.foodcont.2014.01.045>

474 Coenen, M., Kienzle, E., Vervuert, I., & Zeyner, A. (2011). Recent German Developments in the

475 Formulation of Energy and Nutrient Requirements in Horses and the Resulting Feeding

476 Recommendations. *Journal of Equine Veterinary Science*, 31(5–6), 219–229.

477 <https://doi.org/10.1016/j.jevs.2011.03.204>

478 *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 Küçükçetin, 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., Gilmudtinova, L. T., Yamaletdinov, K. S., Gilmudtinov, 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

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

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

582 Miyamoto, M., Seto, Y., Nakajima, H., Burenjargal, S., Gombojav, A., Demberel, S., & Miyamoto, T.
583 (2010). Denaturing Gradient Gel Electrophoresis Analysis of Lactic Acid Bacteria and Yeasts in
584 Traditional Mongolian Fermented Milk. *Food Science and Technology Research*, 16(4), 319–
585 326. <https://doi.org/10.3136/fstr.16.319>

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

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

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

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

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

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

601 Outram, A. K., Stear, N. A., Bendrey, R., Olsen, S., Kasparov, A., Zaibert, V., Thorpe, N., & Evershed, R.
602 P. (2009). The Earliest Horse Harnessing and Milking. *Science*, 323(5919), 1332–1335.
603 <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-razviti-agroturizma-na-altae)
616 [napravlenie-v-razviti-agroturizma-na-altae](https://cyberleninka.ru/article/n/proizvodstvo-kumysa-kak-perspektivnoe-napravlenie-v-razviti-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]. Dair.

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-zhirkokislotoznogo-sostava-](https://cyberleninka.ru/article/n/sravnitel'naya-otsenka-zhirkokislotoznogo-sostava-indeksov-aterogennosti-i-trombogenosti-moloka-razlichnyh-vidov-selskohozyaystvennyh)
641 [indeksov-aterogennosti-i-trombogenosti-moloka-razlichnyh-vidov-selskohozyaystvennyh](https://cyberleninka.ru/article/n/sravnitel'naya-otsenka-zhirkokislotoznogo-sostava-indeksov-aterogennosti-i-trombogenosti-moloka-razlichnyh-vidov-selskohozyaystvennyh)

642 Skorodumova, A. M. (1961). *Dietary and therapeutic dairy products.* (2nd ed.). Medgiz.
643 http://alldata.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.

675

1 Figure legends

2

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

4

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

6

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

8

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

10

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

12

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

16

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

19

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

23

Table 1

Horse population in Central Asian and bordering countries.

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

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.

References	Mare			%			Human		%		Cow			%		
	(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 * 6.38	2,4	2,4	-	9,9	11,2	-	3,1	2,9	26,5	20,4	1,9	1,7	-	5,6	5,2	-

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
A dai	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>cartilagenosus</i> Micoderma 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

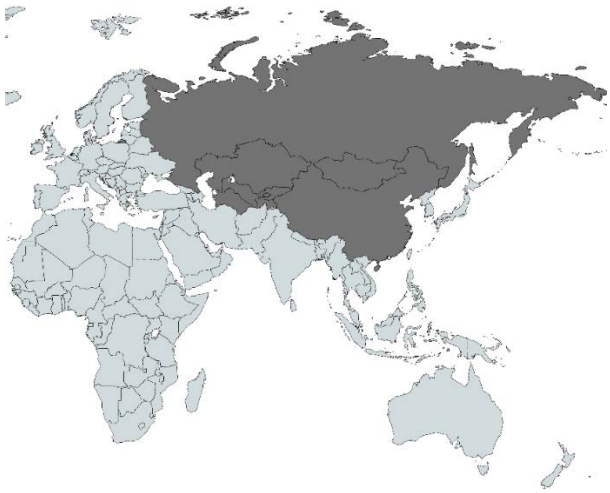


Figure 1

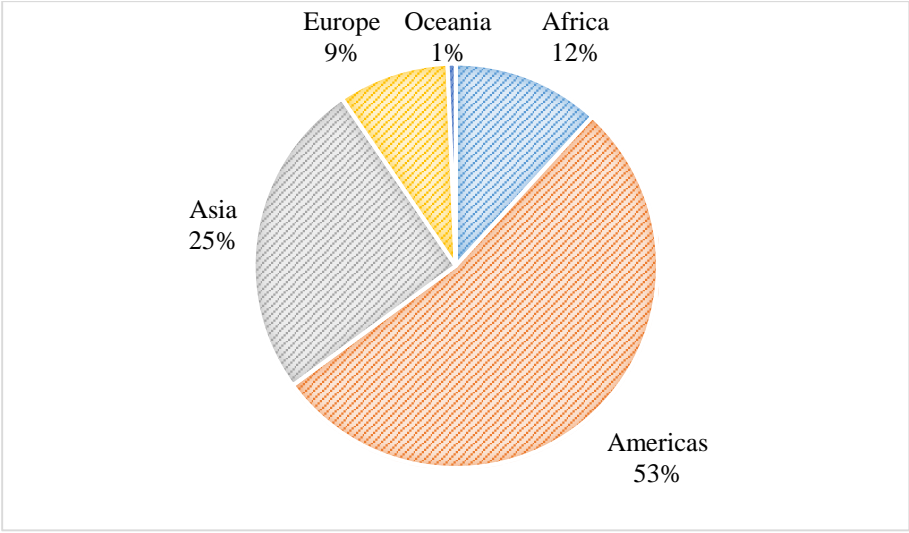


Figure 2

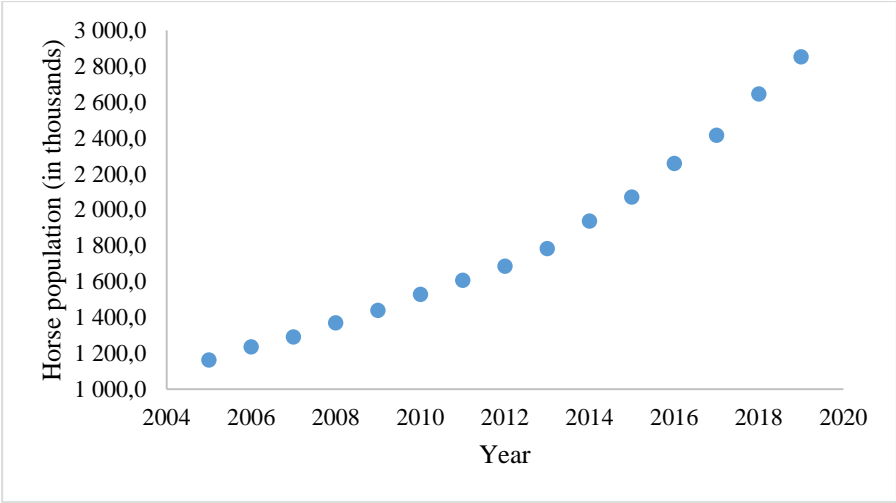


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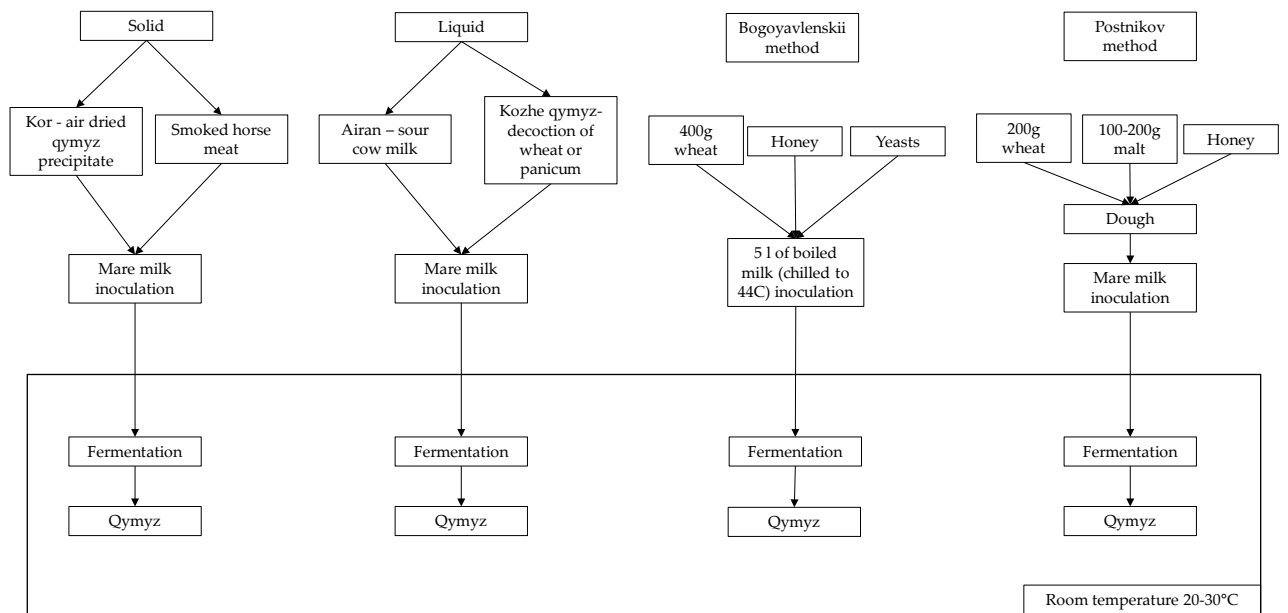


Figure 4



A



B

Figure 5

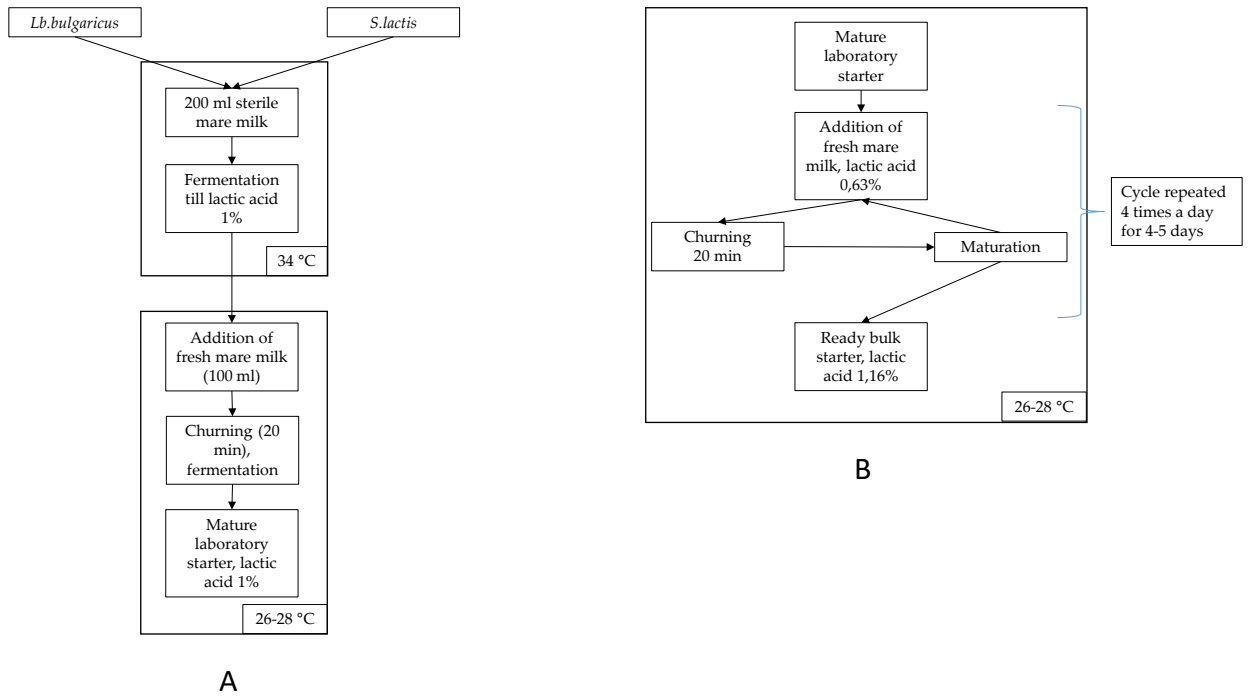


Figure 6

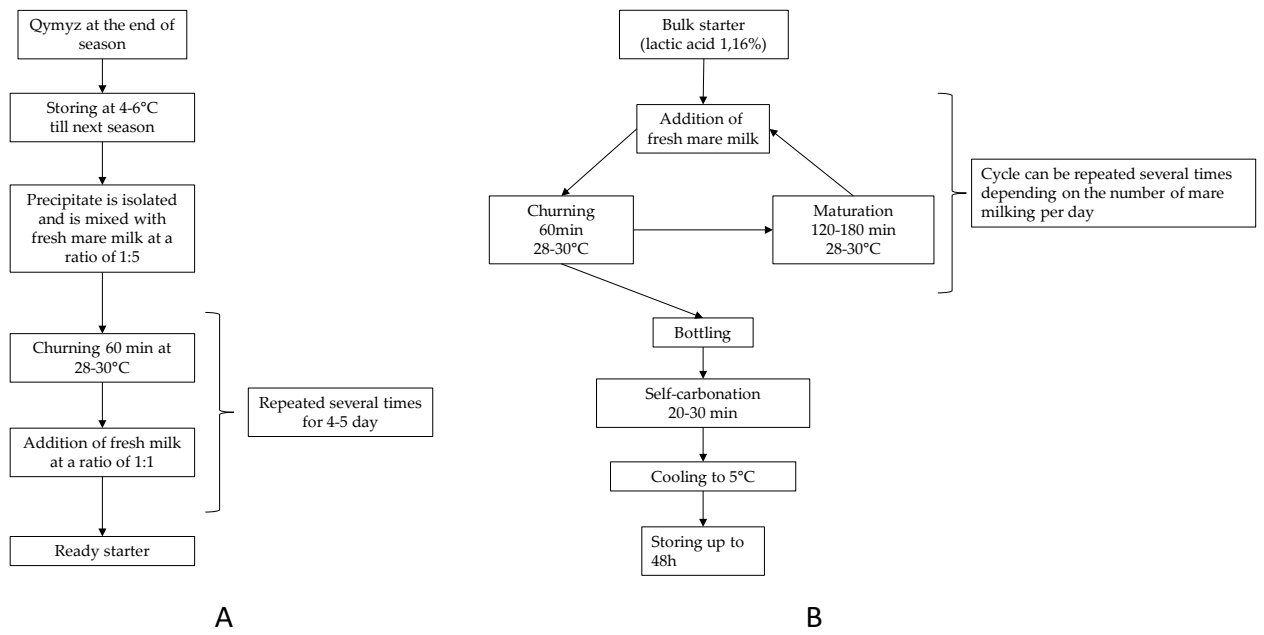


Figure 7

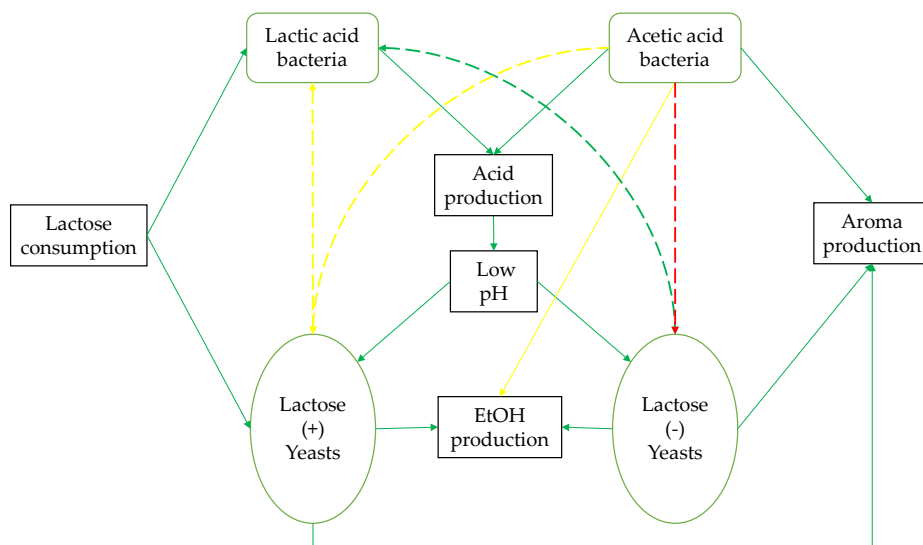


Figure 8