Nomadic Tradition, Therapeutic Function and Microbiota of Airag, Mongolian Fermented Mares’ Milk: A Review

Seung-Bae Lee, Suk-Ho Choi*

Abstract

The objectives of this review were to survey nomadic tradition and technology of airag, Mongolian fermented mares’ milk, therapeutic evidences of airag ingestion and current status of microbiological researches with emphasis on probiotics from airag. The starter cultures for airag making in the central Asian steppes include goats’ milk yogurt, old airag made in the previous year, fermented roasted millet in milk called as hurunge and fresh airag obtained from neighbours. The airag has been shown to have therapeutic potentials for curing and preventing chronic diseases which is related with alimentary canals, circulation systems, and immune systems. The major lactic acid bacteria isolated from airag were *Lactobacillus* (*Lb.*) *helveticus, Lb. plantarum* and *Lb. casei*. The lists of probiotic lactic acid bacteria isolated from airag include various strains of *Lb. casei, Lb. helveticus, Lb. fermentum, Lb. acidophilus, Lb. plantarum, Enterococcus durans* and *Leuconostoc mesenteroides*. The major microorganisms contributing to fermentation of airag are expected to be *Lb. helveticus* and *Kluyveromyces marxianus*. More studies are required to determine optimum condition to make airag with good quality.

Key words airag, koumiss, lactic acid bacteria, probiotic, yeast, therapeutic

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1. Introduction

Airag is a traditional fermented mares’ milk in Mongolia. It is also called as koumiss and chigee in China, Russia and other central Asian countries. The Mongolian nomads ferment fresh mares’ milk during the seasons from late spring to early autumn to produce the sparkling, mildly alcoholic, sour tasting beverage which is used for celebrating holidays like the Naadam festival and other ceremonial occasions and consumed as a wholesome beverage which provide rich nutrients for herders and his family members. The Mongolian creates even so-called ‘airag therapy’ which combines traditional medicine with airag consumption to help in the treatment of chronic diseases, such as hepatitis, ulcer, tuberculosis, etc.

The potential beneficial effects of airag on the prevention of chronic disease described above are expected to be due to probiotic lactic acid bacteria which may colonize intestine to suppress growth of putrefactive bacteria and pathogens in colon and enhance immune function of host cells. Since beginning of 21st century, many research articles regarding characteristics of lactic acid bacteria and yeasts which propagate in airag have been published. Commercially viable probiotics have been isolated from airag and selected to apply for development of functional fermented milk and dietary supplements. However, limited researches on characteristics of mixed fermentation of airag in combination of lactic acid bacteria with yeasts have been performed so far.

The objective of this review was to survey scientific articles regarding tradition of airag production in Mongolia, therapeutic evidence of airag in the treatment of chronic diseases and microorganism involved in fermentation of airag which is
health-functional food as well as refreshing beverage.

2. Airag as a traditional diet of Mongolian nomads

For thousands of years, Mongolian nomads have developed their own livelihoods, pastoral nomadism, to subsist in the country’s cold, dry climate which is marginal for agricultural crop production (Bat-Oyun et al., 2015). They traditionally consume meat during winter and spring and milk products during summer and autumn. Mongolian livestock for milk production includes cow, goat, ewe, mare, camel, yak and reindeer. Thus, the nomads have been either consuming fresh milk or producing various kinds of traditional fermented dairy products, e.g., airag (alcoholic fermented milk), tarag (fermented milk), isgelen tarag (fermented milk), qoormog (fermented milk), byaslag (cheese), eejgiy (cheese) and aarool (cheese), which provide nutrition without the slaughter of livestock (Uchida et al, 2007).

Airag is a mildly alcoholic, sour-tasting fermented drink made from unpasteurized fresh mares’ milk and is a very popular beverage in Mongolia. The fermented mares’ milk is also produced and called as koumiss in Kazakhstan, Krygyzstan, Tajikistan, Uzbekistan, some central regions of Russia, and Xinjiang and Qinghai of China and as chigee in Inner Mongolia of China by the people of the Central Asia steppes, including Turks, Bashkirs, Kazakhs, Yakuts, and Uzbeks in addition to Mongolian. Airag is also a sacred beverage, used for the Naadam festival, ‘Tsagaan sar’ (Lunar New Year), weddings and other celebratory occasions.
Within Mongolian culture, airag symbolizes welcome, respect, and mutual understanding.

Molodin et al. (2008) reported that the Kazakh Mongolians representing a part of the ethnic-political communities of Mongolia hold the spring-summer rituals related to the making of the first koumiss. Special celebrations are also carried out on the day when mares for milking are separated from the herd. (Fig. 1). The ritual ceremony of first mare milking in the summer pasture is regarded as more important than other milking rituals and is linked to the hope of increased livestock and an abundance of airag and other milk products.
3. Consumption and production of airag

It is estimated that 30 million consume mares’ milk regularly throughout world (Zhou et al, 2009). Average daily intakes of fermented mares’ milk by children of Kazakh ethnicity at age 4-21 in rural Kazakhstan ranged 250-280 mL/day in 1950, which were comparable to or slightly less than those of fresh cows’ milk consumptions in some cases (Schwerin et al, 2010). The children of Kazakh ethnicity at age of 1-6 consumed 150-440 mL/day of fresh mares’ milk as well as 160-410 mL/day of fresh cows’ milk. However, children of Russian ethnicity in rural Kazakhstan consumed neither fresh mares’ milk nor fermented mares’ milk. These facts showed that airag plays an important role in the diet of Mongolian and Kazakh.

Intensive production of airag occurred in the central Mongolia, but less in surrounding areas, except along the western border (Bat-Oyun et al., 2015). High horse-density in the central steppes and forest steppes provides an eco-climatological explanation, but the density pattern cannot explain inadequate production of airag in eastern area of Mongolia. The central region with the most active production of airag are home to Khalkh Mongolians and the western border of the country in the Bayan-Ulgii provinces are inhabited by Kazakh Mongolians who also consume the fermented mares’ milk called as koumiss and horse meat. However, Buryat Mongolians in North Mongolia are known to consume a greater amount of cows’ milk products and to produce little airag from mares’ milk. It is suggested that factors such as culture and ethnicity in addition to eco-climatological conditions may contribute to the regional dependence of the airag production in Mongolia.
4. Technology for airag making

The traditional method in Mongolia of making a starter culture for the first fermentation of airag often uses goats’ milk yoghurt (Bat-Oyun et al., 2015). The Mongolian also use an airag preparation made in the previous year (Ishii, 1999; Koroleva, 1988). Enhancing yeast propagation in the goats’ milk yogurt requires shaking it to promote yeast growth and keeping in a warm place for proper fermentation. After full fermentation, the yogurt is mixed with mares’ milk. The mixtures are kept in a cattle-skin bag, called huhuurs in Mongolia, and stirred regularly from top to bottom with a special wooden stick until the mixture is well fermented. Skin processing for the bag is among the traditional trades in Mongolia and is carried out according to the old technologies (Molodin et al., 2008). The modern herders use various other types of containers, such as plastic container, wooden buckets, aluminum ware, iron ware, and etc (Fig 2).

Fig 2. The cattle-skin bag used to prepare airag and the ger, a Mongolian tent
Mongolian nomadic families in Inner Mongolia of China used a starter culture, called as hurunge, for traditional fermented dairy products such as chigee (fermented mares’ milk), airag (fermented cows’ milk) and hogormag (fermented camels’ milk) (Shuangquan et al., 2006). Hurunge which means ‘capital’ in the Mongolian language is considered to consist of invisible living things and believed as a gift from Buddha or God. Hurunge is made by following various methods each summer. One of the typical methods is as follows: 250g of Mongolia roasted millet, a cereal grain, is placed in a cloth bag, which is then immersed for 2–3 min in hot water for softening. Then, it is soaked in 3–4 L of fresh mares’, cows’, or camels’ milk, and kept in ambient temperature (approximately 15–25°C) for 3–7 days for propagation of natural microflora. After the natural fermentation, raw milk is added twice a day with mixing for approximately 10 min and fermentation of the mixture is continued. The quality of hurunge affects the taste of the fermented products (Wu, 1986). Hurunge is stored in the shade after drying or by freezing at −20°C for future use. The foods consumed by nomads, such as roasted millet, millet and raisin, are also used to make hurunge.

The first fermentation of airag requires two or three weeks of stirring routine which is done several times a day. Each stirring session requires several thousand repetitions to aerate the mass and to activate the fermentation process. During the fermentation of airag, storage temperature is maintained at 20–30°C. The regular stirring process is repeated every day throughout summer, after new batch of fresh milk is added each evening to a portion of the airag leftover in order to promote growth of yeasts. When strong foamy texture and characteristic sour taste are achieved, airag is ready to consume. Fermentation results in up to 2% alcohol content and low pH less than
4.0 (Liu et al. 2011).

Choi (2016) reported that the airag samples collected from nomad family in Ulaanbaatar, Mongolia contained 0.10–3.36% lactose, 1.44–2.33% ethyl alcohol, 1.08–1.62% lactic acid and 0.12–0.22% acetic acid. The microbiological counts of lactic acid bacteria and yeasts in the airag samples were 8.04–8.76 logCFU/mL and 6.43–7.87 logCFU/mL, respectively. It was suggested that the highly variable biochemical compositions of the airag samples indicated inconsistent quality due to natural fermentation. The chemical compositions of koumiss produced in China by nomad families were reported as shown in Table 1. The koumiss samples from Qinghai had higher content of lactose, higher titratable acidity and lower content of alcohol than those from Inner Mongolia and Xinjiang (Mu et al., 2012). These results suggested that alcohol fermentation in koumiss from Qinghai was less active than those from Inner Mongolia and Xinjiang of China and that sufficient alcohol fermentation is required to lower lactose content of koumiss.

Table 1. Chemical composition of koumiss from Qinghai, Xinjiang, and Inner Mongolia in China (Mu et al., 2012)

<table>
<thead>
<tr>
<th>Sampling location</th>
<th>Fat (g/100 mL)</th>
<th>Protein</th>
<th>Lactose</th>
<th>Alcohol</th>
<th>Titratable acidity (±T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner Mongolia</td>
<td>1.47–1.92</td>
<td>1.96–2.17</td>
<td>1.24–2.05</td>
<td>1.85–2.15</td>
<td>88.2–104.1</td>
</tr>
<tr>
<td>Xinjiang</td>
<td>1.78–1.91</td>
<td>1.83–2.25</td>
<td>1.52–2.00</td>
<td>1.78–2.02</td>
<td>88.2–106.1</td>
</tr>
<tr>
<td>Qinghai</td>
<td>1.72–1.97</td>
<td>1.95–2.19</td>
<td>2.54–2.72</td>
<td>1.12–1.50</td>
<td>111.9–122.2</td>
</tr>
</tbody>
</table>

Koumiss is also manufactured commercially by using various lactic acid bacteria and *Kluyveromyces marxianus* as starter (Varnam and Sutherland, 1994). Three types of koumiss exist, so-called ‘strong’, ‘moderate’ and ‘light’ koumiss depending on the lactic acid contents
(Danova et al., 2005). 'Strong' koumiss is generated by lactic acid bacteria, such as *Lb. delbrueckii* ssp. *bulgaricus*, which acidify the milk to pH 3.6-3.3. 'Moderate' koumiss contains lactic acid bacteria, such as *Lb. acidophilus, Lb. plantarum* and *Lb. casei* that lower the pH to 4.5-3.9. 'Light' koumiss is a slightly acidified product with pH 4.5-5.0 and harbors *Lactococcus lactis* and *Streptococcus thermophiles*.

5. **Nutritional richness and therapeutic effect of airag**

Airag is rich in potentially health-promoting probiotics, such as lactic acid bacteria and yeasts, well as essential nutrients such as calcium, proteins and vitamins which originate from mares’ milk. For centuries, airag has been considered as not only a kind of food, but also a nutrient-rich food with medicinal properties on alimentary canal, circulation systems, and immune systems (Lozovitch, 1995). In China and Mongolia, Mongolian people have created the “airag therapy” which combined traditional medicine with airag consumption to help in the treatment of hepatitis, chronic ulcers, tuberculosis, etc.

The composition of mares’ milk is significantly different from that of cows’ milk and similar to human milk (Malacarne et al., 2002). The amino acid composition of its protein is also closer to that of human milk than cows’ milk or goats’ milk (Caspo-Kiss et al., 1995) In addition, mares’ milk is rich in polyunsaturated fatty acids which consist of essential fatty acids which must be supplied from the foods (Caspo et al., 1995).

However, mares’ milk has been recognized as a strong laxative because of high content (6.5%) of lactose which cannot be digested and absorbed in the small intestine of most Asians in adult age who lack lactose-hydrolyzing enzyme, lactase, in the intestinal mucosa and
thus suffer from lactose intolerance. Since lactose can be converted extensively into lactic acid and ethanol during fermentation of airag by lactic acid bacteria and yeasts, respectively, the residual lactose (0.2%−2.2%) in airag should not cause diarrhea and abdominal cramp which are frequent symptoms of lactose intolerance (Choi, 2016; Brown–Riggs, 2016).

The beneficial effects of koumiss on humans and experimental animals were reported by the recent studies. Sukhoj et al. (1986) reported that koumiss is most effective in the treatment of intestinal dysbacteriosis, when shubat, koumiss and kefir were given to three groups of patients with chronic enteritis. Supplement of diet with koumiss for chronic enteritis patients promotes vitamin B₁₂ absorption and its blood content (Zhangabylov et al., 1986). Diet therapy including koumiss only and exercise program only as well as diet therapy including koumiss with exercise program for sedentary persons decreased triglyceride and cholesterol levels in their bloods, but the diet therapy including koumiss with exercise program showed significant decrease (Donmez et al., 2014).

Koumiss as a feed supplement for white mice and chickens was found out to make notable increase in the number of animals exhibiting strong immune responses to the antigens they had been previously immunized with (Fedechko et al., 1995). Feeding of mice with koumiss formulation increased their body weights compared to controls. Koumiss formulation increased expression in mouse kidney of peroxisome proliferator-activated receptor-α (PPAR-α) and PPAR-β/δ, which may protect kidney against environmental changes (Sari et al., 2014) and also increased expression of platelet derived growth factor-c (PDGF-c) and platelet derived growth factor receptor-α which may be applied for treating liver and kidney disease and for treating
retardation of growth and development, protect mouse liver and kidney (Bakir et al., 2015).

Chen et al. (2010) suggested that koumiss had high angiotensin I-converting enzyme (ACE) inhibitory activity which made it attractive as a health-enhancing ingredient in the production of functional foods with antihypertensive activity. The active fractions contained peptides the molecular weights of which were less than 3 kDa. Guo et al. (2015) reported that lactobacilli isolated from koumiss exhibited higher bile tolerance, adhesion to HT-29 cells, cholesterol removal and percentage of bile salt hydrolase-positive strains than those from suan-tsai, pickled Chinese cabbage, and suggested that koumiss could be considered a better source of cholesterol-lowering probiotics. These above-described studies may provide evidences about the beneficial effects of koumiss, especially on cardiovascular health.

6. Lactic acid bacteria in airag and their probiotic properties

Since the beneficial effects of airag on the prevention of the chronic diseases are expected to be due to probiotic microorganisms, mostly lactic acid bacteria, extensive studies have been done on the distribution of lactic acid bacteria in airag (koumiss) collected in Mongolia, China, and Russia (Table 2) and on the characterization of isolated probiotics.

6.1. Distribution of lactic acid bacteria

The airag samples collected in various regions of Mongolia contains
*Lb. helveticus* as the predominant lactic acid bacterial species (Choi, 2016; Sun et al., 2010a; Takeda et al., 2011; Uchida et al., 2007; Watanabe et al., 2008). *Lb. helveticus* (19 isolates), *Lb. plantarum* (6 isolates) and *Lb. casei* (1 isolate) from five airag samples collected at households in Ulaanbaatar, Mongolia were identified by Sun et al. (2010a). The major lactic acid bacteria of airag samples collected from three nomadic families in Donto–Govi prefecture in Mongolia consisted of *Lb. helveticus* and *Lb. kefiri* (Uchida et al., 2007). Watanabe et al. (2008) reported that *Lb. helveticus* (21/22) and *Lb. kefiranofaciens* (14/22) were major lactic acid bacteria isolated from 22 Airag samples collected in Tov, Bulgan, Arhangai, Uburhangai, Umungobi, and Dundgobi provinces which are located in various regions of Steppe, Forest–steppe, Gobi Desert of Mongolia, Takeda et al. (2011) isolated 67 lactic acid bacteria isolates from 7 airag samples collected from Ulaanbaatar in Mongolia, *Lb. helveticus, Lb. delbrueckii* ssp. *lactis*, and *Lb. fermentum* were dominant species at the levels of 46.2%, 22.4%, and 11.9%, respectively.

However, the distributions of lactic acid bacteria in the koumiss samples obtained in China are variable depending on the sampling regions. An et al. (2004) isolated 170 lactic acid bacteria from chigee collected from Inner Mongolia, *Lactobacillus plantarum, Lactobacillus pentosus*, and *Lactococcus lactis* ssp. *cremoris* were the major lactic acid bacteria at the rate of 48, 33 and 19%, respectively. Wu et al. (2009) reported that the dominant lactobacilli species in koumiss from Inner Mongolia, China were *L. casei, L. helveticus*, and *L. plantarum* at the levels of 35, 21, and 17%, respectively. Later, Sun et al. (2010b) reported that *L. helveticus, L. casei, and L. plantarum* appeared to be dominant species in koumiss collected from Xinjiang, Inner Mongolia and Qinghai in China, respectively.
These results indicated that *Lb. helveticus* is predominant lactic acid bacteria in airag produced in Mongolia and koumiss in Xinjiang of China (Table 2). However, *Lb. casei, Lb. plantarum* and *Lb. helveticus* have been frequently isolated from koumiss produced in Inner Mongolia and Qinghai of China, though their proportions in koumiss are different between the studies.

### 6.2. Characteristics of probiotic lactic acid bacteria

Many studies have isolated lactic acid bacteria from airag in Mongolia and koumiss in China based on tolerance in gastrointestinal environment, antimicrobial property and adhesion to cell such as Caco–2 cell. The in vivo beneficial properties of the probiotics to manage liver injury, hypertension, cholesterol in serum, etc are also elucidated. Takeda et al. (2011) screened 543 lactic acid bacteria isolates, including *Lb. delbrueckii* ssp. *bulgaricus, L. helveticus, L. fermentum, L. delbruckii* ssp. *lactis* and *Lc. lactis* ssp. *lactis* isolated from Mongolian fermented milks for tolerance to low pH and bile acid, gas production from glucose and adherence to Caco–2 cell. They found 10 strains possess probiotic properties, and identified most of them as *Lb. plantarum, and Lb. paracasei* ssp. *paracasei*. Bilige et al. (2009) screened *Lb. helveticus* isolates from home-made airag in Mongolia and identified *Lb. helveticus MG2–1* which is most effective in tolerance to artificial gastrointestinal juice, sodium taurocholate deconjugation, and cholesterol removal and adhesion to Caco–2 cell.

Table 2. Distribution of lactic acid bacteria in the samples of airag collected in Mongolia, China and Russia
<table>
<thead>
<tr>
<th>Sampling location and country</th>
<th>Lactic acid bacteria identified</th>
<th>LAB counts (logCFU/mL)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ulaanbaatar (Mongolia)</td>
<td><em>Lb. helveticus</em> (75%), <em>Lb. plantarum</em> (23%), <em>Lb. casei</em> (4%)</td>
<td>7.18</td>
<td>Sun et al., 2010a</td>
</tr>
<tr>
<td>Ulaanbaatar, Altanbulag (Mongolia)</td>
<td><em>Lb. helveticus</em> (46%), <em>Lb. delbrueckii ssp. lactis</em> (22%), <em>Lb. fermentum</em> (12%)</td>
<td>Na</td>
<td>Takeda et al., 2011</td>
</tr>
<tr>
<td>Ulaanbaatar (Mongolia)</td>
<td><em>Lb. helveticus</em> (50%), <em>Lb. kefiranofaciens</em> (11%), <em>Lb. kefiri</em> (11%), <em>Enterococcus faecalis</em> (11%)</td>
<td>8.04-8.76</td>
<td>Choi, 2016</td>
</tr>
<tr>
<td>Arhangai, Bulgan, Dundgobi, Tuv, Uburhangai, Umnugobi (Mongolia)</td>
<td><em>Lb. helveticus</em> (51%), <em>Lb. kefiranofaciens</em> (19%), <em>Lb. casei</em> (7%), <em>Leu. mesenteroides</em> (7%), <em>Lb. plantarum</em> (4%), <em>Lc. lactis</em> ssp. <em>lactis</em> (4%)</td>
<td>7.78</td>
<td>Watanabe et al., 2008</td>
</tr>
<tr>
<td>Donto-govi (Mongolia) Xinjiang (China)</td>
<td><em>Lb. kefiri</em>, <em>Lb. helveticus</em> <em>Lb. helveticus</em> (83%), <em>Lb. plantarum</em> (8%), <em>Lb. casei</em> (3%)</td>
<td>8.62-9.58</td>
<td>Uchida et al., 2007</td>
</tr>
<tr>
<td>Inner Mongolia (China)</td>
<td><em>Lb. plantarum</em> (50%), <em>Lb. pentosus</em> (35%), <em>Lc. lactis</em> ssp. <em>cremoris</em> (17%)</td>
<td>Na</td>
<td>An et al., 2004</td>
</tr>
<tr>
<td>Inner Mongolia (China)</td>
<td><em>Lb. casei</em> (35%), <em>Lb. helveticus</em> (21%), <em>Lb. plantarum</em> (17%), <em>Lb. corniformis</em> (10%)</td>
<td>6.82 - 8.76</td>
<td>Wu et al., 2009</td>
</tr>
<tr>
<td>Inner Mongolia (China)</td>
<td><em>Lb. casei</em> (34%), <em>Lb. helveticus</em> (29%), <em>Lb. plantarum</em> (24%)</td>
<td>6.98-7.46</td>
<td>Sun et al., 2010b</td>
</tr>
<tr>
<td>Qinghai (China)</td>
<td><em>Lb. plantarum</em> (64%), <em>Lb. helveticus</em> (27%)</td>
<td>8.09</td>
<td>Sun et al., 2010b</td>
</tr>
</tbody>
</table>

Na: Not available

*Lb. casei* Zhang is the most extensively studied probiotic lactic acid bacteria from koumiss of Inner Mongolia by Zhang and his colleagues (Wu et al., 2009; Ya et al., 2008; Zhong et al., 2012, Wang et al., 2013, Zhang et al., 2014). *Lb. casei* Zhang was selected based on acid resistance, bile tolerance, antibacterial activity and viability during refrigerated storage. Its *in vivo* therapeutic properties which include enhancing
immunity functions, lipid metabolism and liver protection were characterized. Only live \textit{Lb. casei} Zhang elicited a wide range of immune responses, which include increased production of interferon-\(\gamma\) and depression of tumor necrosis factor-\(\alpha\) levels, implying that it may be a valuable strain for probiotic use in human. Zhang et al. (2014) reported that consumption of \textit{Lb. casei} Zhang by human subjects promoted beneficial bacteria and inhibited harmful bacteria in feces. Consumption of \textit{Lb. casei} Zhang revealed positive relationships with \textit{Prevotella}, \textit{Lactobacillus}, \textit{Faecalibacterium}, \textit{Propionibacterium}, \textit{Bifidobacteria}, \textit{Lachnospiraceae}, and an unidentified genus from \textit{Bacteroidaceae} and negative relationships with \textit{Clostridium}, \textit{Phascolarctobacterium}, \textit{Serratia}, \textit{Enterobacter}, \textit{Shigella}, \textit{Shewanella}.

Zhao et al. (2014) reported that \textit{Lb. casei} \(H_4\) protected mice against alcoholic liver injury by increasing antioxidant activity. Whey fermented liquid (WFL) which was prepared by incubating with \textit{Lb. casei} \(H_4\) was fed to alcohol-induced mice. Alcohol consumption significantly reduced the activity of superoxide dismutase and glutathione peroxidase, while lowering glutathione content and increasing levels of aspartate aminotransferase, alanine aminotransferase, total triglyceride, malondialdehyde and chtochrome P450 2E1. The treatment with WFL significantly attenuated the increased levels of aspartate aminotransferase, alanine aminotransferase, triglyceride, malondialdehyde and chtochrome P450 2E1, while increasing superoxide dismutase, glutathione peroxidase, and glutathione levels in the liver.

Sun et al. (2009) isolated from koumiss in Xinjiang \textit{Lb. helveticus} ND01 which produced high levels of angiotensin l-converting enzyme (ACE)-inhibitory activities and high content of \(\gamma\)-aminobutyric acid (GABA) in fermented skim milk and suggested that the strain possessed good potential for application in the management of hypertension. \textit{Lb.}
*helveticus* NS8 which was isolated from koumiss in Inner Mongolia is reported to protect against TNBS (2,4,6-trinitrobenzene sulfonyl acid)-induced murine colitis (Rong et al. 2015). Co-culture with *Lb. helveticus* NS8 induced an increased level of secretion of anti-inflammatory cytokine IL-10 in peripheral blood mono-nuclear cells and diminish proinflammatory effects of lipopolysaccharide in mouse macrophage cell line RAW264.7 by inducing higher levels of IL-10.

Table 3, Distribution of yeasts in airag

<table>
<thead>
<tr>
<th>Sampling location and country</th>
<th>Identified yeasts</th>
<th>Yeast counts (log CFU/mL)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner Mongolia (China)</td>
<td><em>Kluyveromyces marxianus</em> (27%), <em>Kazachstania unispora</em> (17%), <em>Saccharomyces cerevisiae</em> (17%)</td>
<td>6.56–7.46</td>
<td>Mu et al., 2012</td>
</tr>
<tr>
<td>Xinjiang (China)</td>
<td><em>Kluyveromyces marxianus</em> (23%), <em>Saccharomyces cerevisiae</em> (17%), <em>Kazachstania unispora</em> (13%)</td>
<td>6.61–7.88</td>
<td></td>
</tr>
<tr>
<td>Qinghai (China)</td>
<td><em>Saccharomyces cerevisiae</em> (25%), <em>Kazachstania unispora</em> (22%), <em>Kluyveromyces marxianus</em> (14%)</td>
<td>5.23–6.53</td>
<td></td>
</tr>
<tr>
<td>Arhangai, Bulgan, Dundgobi, Tuv, Uburhangai, Umnugobi (Mongolia)</td>
<td><em>Kluyveromyces marxianus</em> (41%), <em>Kazachstania unispora</em> (21%), <em>Saccharomyces cerevisiae</em> (15%)</td>
<td>5.44–8.24</td>
<td>Watanabe et al., 2008</td>
</tr>
<tr>
<td>Donto–Govi (Mongolia)</td>
<td><em>Kluyveromyces wickerhamii</em>, <em>Saccharomyces dairensis</em></td>
<td></td>
<td>Uchida et al., 2007</td>
</tr>
</tbody>
</table>

**7. Yeasts and alcoholic fermentation in airag**

Yeasts in airag ferment milk sugar, lactose, in mares’ milk into ethanol and carbon dioxide to produce carbonated mildly alcoholic drink. Table 3 shows that *Kluyveromyces marxianus* which utilizes lactose has strong influence in alcoholic fermentation of airag (Gadaga et al., 2011; Mu et al, 2012; Watanabe et al., 2008).

Mu et al. (2012) reported that 96 koumiss samples from Inner
Mongolian, Qinghai and Xinjiang of China harbored yeast populations at 5–7 log CFU/mL. The major yeast species were *Kluyveromyces marxianus*, *Kazachstania unispora*, and *Saccharomyces cerevisiae*. However, there were differences in yeast numbers and proportions of these yeasts between the koumiss samples from Inner Mongolia, Xinjiang and Qinghai. The frequency of *Kluyveromyces marxianus* in the koumiss samples from Qinghai were lower than those in the koumiss from Inner Mongolia and Qinghai. The koumiss samples from Qinghai also contained less alcohol and more lactose than those from Inner Mongolia and Xinjiang. These results suggested that the preparation method of koumiss in Qinghai may not promote proper growth of *Kluyveromyces marxianus* to produce alcohol by utilizing lactose.

Watanabe et al. (2008) showed that 22 airag samples collected from Steppe, Forest-steppe, Gobi and Desert in Mongolia contained yeast populations at 7.41 log CFU/mL. The lactose-fermenting *Kluyveromyces marxianus* was isolated predominantly from all of 22 airag samples in Mongolia and *Kazachstania unispora*, and *Saccharomyces cerevisiae* were also frequently isolated from 13 and 10 airag samples, respectively.

Yeast population in koumiss from Inner Mongolia may be originated from hurunge used as koumiss starter. Shuangquan et al. (2006) reported that the 30 strains of yeasts isolated from hurunge identified as *Saccharomyces cerevisiae* (10 strains), *Candida kefyr* (seven strains), synonym of *Kluyveromyces marxianus*, *Kluyveromyces marxianus* var. *lactis* (three strains), *Candida krusei* (six strains) and *Candida valida* (four strains). *Saccharomyces cerevisiae* dose not ferment lactose, but galactose, glucose, maltose, raffinose and sucrose. However, *Candida kefyr* ferments all six carbohydrates including lactose. Thus, *Candida kefyr* (synonym of *Kluyveromyces*
marxianus) seems to become dominant yeast species in koumiss, since mares’ milk supply lactose for the yeast. The major yeast species from airag samples collected at three nomadic families in Donto-Govi prefecture in Mongolia (central Mongolia) was reported to be *Saccharomyces dairensis* in the study done by Uchida et al. 2007.

Wulijideligen et al. (2013) reported that mixed cultures of nine lactic acid bacteria and yeast strains isolated from airag of Inner Mongolia showed high viable counts and strong acid production compared to the single cultures. *Candida kefyr* produced ethanol in the single and mixed cultures, where non-lactose-fermenting *Saccharomyces cerevisiae* produced ethanol only in the mixed cultures. The results suggests that non-lactose-fermenting yeasts utilize monosaccharides produced by lactic acid bacteria enzyme to promote cell growth.

8. Conclusion

Airag occupies preeminent status in the dietary cultures of Mongolians. The recipes to prepare airag and its starter culture seem to affect distribution of lactic acid bacteria and yeasts and quality of the final preparation. The therapeutic evidences of airag in clinical practices and animal testing have promoted many studies to isolate probiotic lactic acid bacteria which may be applied to production of functional fermented milk and diet supplements. However, researches for manufacturing airag of good quality are lacking. Airag–like fermented cows’ milk of good quality and with health functional effects
may diversify dairy product market and increase consumption of milk in Korea as well as Mongolia.

References


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