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Research Article

Intensification of Mare's Milk Production at Designed Kumiss Farms

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Abstract: The aim of this research was to study the global experience in designing kumiss farms and to evaluate the influence of machine and manual milking on the quantitative and qualitative composition of mare's milk in kumiss farms of the Zhambyl region. The object of the study was the Kazakh horse breed from two farms in the Zhambyl region: Ertai farm of Zhualyn district and Shaushen farm of Turar Ryskulov district. Experimental groups were formed using the method of pair analogues. Manual and machine milking procedures were carried out after manual stimulation of the udder to activate the milk let-down reflex, in the presence of foals that had not been allowed to suckle for three hours prior. International experience shows that optimal feeding and housing conditions significantly affect mare milk yield, while origin and breed influence udder morphology and suitability for machine milking. Most mares adapt to milking without suckling, although 10-15% without foals still yield poorly. In herd horse breeding in Kazakhstan, the suckling method remains economically justified, as the main objective is offspring rearing, with only part of the milk used for kumiss. In specialized dairy farms, however, the priority is maximizing milk production. The study found that with manual milking, udder filling was 5.2% lower compared to machine milking. Machine milking increased average udder capacity by 0.52 kg (23.5%) and average milk yield per session by 0.47 kg (58.8%) compared to manual milking. In Kazakh mares, the cisternal fraction of milk accounted for 18.1% and the alveolar fraction for 81.9% of total yield per milking.

Keywords: Horse Breeding, Mares, Kumys Farm, Milking Technology, Udder, Milk Yield

Introduction

Recently, an industrial production of kumiss is used more extensively in connection with increased demand on this drink and awareness of its potential health benefits. Industrial kumiss differs significantly from traditional kumiss by quality (Zhao *et al*., 2024). The peoples of Central Asia constantly consume mare's milk as food, and the range of dairy products made from natural mare's milk is expanding (Barłowska *et al*., 2023).

Research is being conducted on the effect of machine and hand (manual) milking on the behavior, milk yield and milk composition of mares. It has been established that machine milking significantly increases the fat content in milk (up to 1.63%) compared to hand milking (1.06%) (Caroprese *et al*., 2007).

Fermented milk products are produced or by way spontaneous fermentation or using parties previously produced product, That there is a reverse method pressing (Bintsis and Papademas, 2022). In Kazakhstan, dairy products are produced mainly from cow's milk. Fermented milk products made from mare's milk are in demand (FAO, 2011). However, industrial production of mare's milk is difficult due to the widespread use of manual milking.

At the breeding kumiss complex of the ZAO PZ Semenovsky of the Russian Federation, machine milking of mares is practiced (Chirgin *et al.*, 2019a-c).

Kumiss farms are effectively created where the development of dairy cattle breeding is difficult. Kumiss farms contribute to the ecologically sustainable development of rural area microeconomics (Miraglia *et al.*, 2020).

The method of manual or mechanical milking does not significantly affect the composition of the milk. The study suggests that regular machine milk production using Mongolian mares may increase the economic value of the local breed and provide an additional reason for its conservation (Sandagdorj *et al.*, 2020, 2021).

The results show that machine milking of mares can improve milk yield and overall milk composition without negatively affecting mares' behavior and reactions to people. In particular, milk yield was higher with machine milking (7.69 kg) compared to manual milking (4.91 kg), and milking time was significantly reduced from 5.40 min with manual milking to 1.80 min with machine milking. Machine milking of mares also resulted in higher milk fat content (1.63%) compared to hand milking (1.06%). The milking system did not affect casein content, nitrogen fractions, or somatic cell count (Caroprese *et al.*, 2007).

Mares produce the highest milk yields in the first months of lactation. With year-round production of mare's milk, it is necessary to ensure uniform production of marketable mare's milk, which can only be provided by large horse breeding farms (Ukhov *et al.*, 2016; Oorzhak, 2017; Kurochkina *et al.*, 2021).

Thus, the study of world experience in the design of kumiss farms is a relevant area of research.

The objective of this study is to analyze international practices in the design of kumiss farms and to assess the effects of machine and manual milking on the quantitative and qualitative composition of mare's milk in kumiss farms of the Zhambyl region.

Materials and Methods

Object of research or development: Kazakh horse breed from two farms of Zhambyl region: farm "Ertai" of Zhualyn district, farm "Shaushen" of Turar Ryskulov district.

The formation of experimental groups was carried out using the pair-analogue method (Baimukanov *et al.*, 2024).

Procedures of manual as well as machine milkings were carried out by milking udder of each mare after manual stimulation for activation of milk flow reflex in a presence of foal which earlier during 3 hours were without any udder suckle. During each session of manual and machine milking mares gave small quantity concentrate (≈300 g per milking). There were used milking installations DDA-2M, adapted to mares udders, with average vacuum level of 45 kPa, pulsation frequency of 120 cycles/minute and pulsations ratio of 1:1. Milk yield and time spent on emptying udders (i.e. milking time), were daily registered individually for each mare. Mares were milked manually as well as by machine. Milk yield was recorded with graduated measuring cylinders.

The amount of cisternal and alveolar milk in the udder of mares of the Kazakh horses was determined by separate milking of the udder with DDA-2M milking machine and recording the milked milk during one cycle from June to September 2024. In total, the amount of cisternal and alveolar milk was determined in 40 mares.

Statistical processing of the research data was performed according to the common method of statistical analysis using the Microsoft Excel program. The reliability of the difference between the average values of the characteristics was determined by the Student's t-test (The Basics of Biometrics, 2011).

Results and Discussion

The development of dairy horse breeding is based on deep knowledge of the biological foundations of horse productivity and rational technological solutions for obtaining products from them.

Most kumiss farms are located in regions where herd horse breeding is practiced. The overwhelming majority of these kumiss farms are seasonal. Mare's milk on seasonal farms is produced only in the summer months, on cheap pasture feed, so its production is profitable. Usually, a small part of mares are milked on these farms, only the most milky and well-trained ones. In such conditions, when not all the horses participate in milking, it is difficult to conduct targeted selection of the entire horse population for milk productivity. Milk yield from herd mares is usually low.

There are very few stationary kumiss farms both in regions of herd horse breeding and in those regions where herd horse breeding is not practiced. In all stationary kumiss farms, the production of mare's milk itself is unprofitable. Compared to seasonal farms, the following expenses are added to the cost of milk on stationary farms: maintenance of stable buildings, warehouses and other premises, procurement, storage and distribution of feed, manure removal, organization of mating of mares, maintenance and feeding of stud horses, increased wages of personnel compared to herd horse keeping. Profitable operation of these farms is achieved mainly through the sale of young horses, so the topic of these studies is extremely relevant.

Table 1 shows the biological characteristics of horses taken into account when designing kumiss farms.

Table 1: Biological characteristics of horses

No	Peculiarities	Note
1	Foals are born more developed and mature	In comparison with other types of dairy cattle productivity.
2	Short period of milk feeding	20-25 days
3	Mares have a short lactogenesis period	Significant changes in milk production by the mammary glands are possible
4	Intensive growth of foals at the beginning of ontogenesis	Daily weight gain can be 1-3 kg.
5	High daily milk yield in mares during lactogenesis	Herd horses can weigh up to 15-30 kg.
6	Small udder capacity	1.5-3 kg, therefore three-time milking is practiced. When using machine milking, five-time milking.

Commercial kumiss differs from traditional one in quality (Zhao *et al.*, 2024; Bintsis and Papademas, 2022). Horses are late maturing animals with low fertility and therefore must be used in dairy horse breeding for a long time to ensure the profitability of the industry (Chirgin *et al.*, 2019b). The origin and breed of mares influences the formation of the exterior, morphological parameters of the udder and suitability for machine milking (Chirgin *et al.*, 2021b). The high level of milk productivity of mothers during the period of highest lactation allowed their daughters to become leaders already during the first lactation (Chirgin *et al.*, 2021a).

Based on the above, when forming a dairy herd of mares for kumiss farms, we will study the milk yields of lactating mares and their mothers (according to breeding records). Recommended technologies for a kumiss breeding farm with 100 mares are given in Table 2.

Table 2: Main annual economic indicators of the enterprise

No	Business indicators	Parameters
1	Average annual number of horses.	260 animals
2	Business output of foals per 100 mares.	85 animals
3	Annual culling of mares	15%
4	Weaning foals from their mothers.	At the age of 8 months, with an average live weight of 345 kg for the Russian heavy draft breed, 420 kg for the Lithuanian heavy draft breed, and 180 kg for the Kazakh horse of the Jabe type.
5	Sale of breeding young animals	At the age of one and a half to two years.
6	Production of commercial milk per dairy mare.	The annual milk yield of heavy draft breeds is 3,750 kg, and one forage mare of heavy draft breeds produces 3,000 kg of milk.
7	Production of mare's milk per year.	From 100 mares of heavy draft breeds 3000 c.

When milking without sucking, i.e. without the participation of a foal in the milking process, "chain" milking units are used, in which mares stand in a row one after another. Milking with sucking, i.e. the foal participates in the milking process, is performed using DDA-2M milking units. This unit consists of two parallel stalls, between which the milkmaid's workplace is located. On the other side of the stalls, in special pens, the foals on duty are located (Table 3).

Table 3: Stationary farms with year-round production of mare's milk

No	Name	Option 1	Option 2
1	Maintenance of mares	Tie-up	Loose
2	Keeping in stables	Loose box	In group sections
3	Mechanized milking of mares	Mobile milking machines	Individual milking machines
4	The ways of milking mares	Milking without sucking	Milking with sucking

The milk productivity of suckling mares is 10-24 liters per day, of which 50-70 % is sucked by the foal, and the rest is milked out. The milk yield of mares is greatly influenced by optimal feeding and housing conditions. For example, in stable conditions, dairy mares should be fed individually. In semi-herd conditions, herds of up to 70-80 mares are formed on a dairy farm and driven to good pastures. Mares are grazed on the pasture around the clock, additionally they are given concentrates of 2-3 kg per head, provided with salt in the form of a lick and drinking water.

After foaling, the mare's foal is on 24-hour suckling for the first few days. Frequent suckling by the foal not only stimulates the removal of milk from the mammary gland, but also stimulates the release of lactogenic hormones into the blood as a result of the effect on the pituitary gland. Milk flow in a mare is caused not only by direct stimulation through the nipple receptors, but also by the presentation of her foal, the time and place of milking.

A conditioned reflex of milk ejection is also developed for a specific milkmaid. Many mares give milk only to their milkmaid, and if the milkmaid changes, the milk yield drops sharply. If the previous milkmaid does not return, premature milking of mares often occurs.

Most mares are trained to give milk without suckling, but about 10-15% of mares without a foal still give milk poorly. To do this, one or two suckling foals are placed in the milking parlor during milking, and are brought to the mares as needed. They stimulate milk flow by receiving small portions of milk. Immediately after the milk starts to flow, the foal is taken away and the mare is milked.

In herd horse breeding in Kazakhstan, maintaining the suckling method is economically justified. The main task is to obtain and raise offspring, and only a small part of the milk from the finished milking is used for kumiss.

In specialized dairy farms, the main task is to obtain the maximum amount of milk for kumiss.

In the kumiss treatment sanatorium farms, mares are milked in a milking parlor, where 5-7 animals enter at a time through a split corridor. Stereotypical conditions maintained in the milking parlor, isolated from the outside environment, and group milking create good conditions for milk flow. A mare that has given milk several times without a foal gets used to this and subsequently willingly goes to the milking place herself.

On the distant pastures, mares are milked directly in the steppe, using a pole with a running noose. The milkmaid approaches the mare, places one end of the pole on her neck, and throws the other on the ground and begins to milk. The mare stands still. But this same mare will not let the herder approach her if he tries to catch her.

Kumiss farms are designed as stationary for milking mares (Table 4). This type of structure and design is used in the Russian Federation, Mongolia, the People's Republic of China and the Republic of Kazakhstan.

1. Design of stable sections – loose box (individual), group, mixed (when part of the livestock is kept in stalls, and the other part - in group sections),
2. Keeping mares in stables – tie-up, loose.
3. Keeping of dairy mares - stall, pasture
4. Milking mares – milking mares in stalls, using mobile milking units (complexes) that move between stalls during milking; milking mares in loose boxes or stalls using individual portable milking machines; milking mares manually.
5. The principle of milking mares is milking without sucking
6. Production of mare's milk is year-round, seasonal.

Table 4: Results of the analysis of the design of kumiss farms abroad and in the Republic of Kazakhstan

Name	Russian Federation	People's Republic of China	Mongolia	Republic of Kazakhstan
Design of the stables section	Loose box (individual).	Group	Mixed	Group (Farm "Ertai" of Zhambyl Region, Farm "Shaushen" of Zhambyl Region).
Keeping mares in stables	Tie-up, loose	Tie-up, loose	Tie-up, loose	Tie-up (Farm "Ertai" in Zhambyl Region), loose (Farm "Shaushen" in Zhambyl Region).
Keeping dairy mares	Stall	Stall	Stall	Stall (Farm "Ertai" in Zhambyl Region), loose (Farm "Shaushen" in Zhambyl Region). Pasture in all regions of Kazakhstan.
Milking mares	Milking mares in stalls, using mobile milking units (complexes), which move between stalls during milking. Milking mares in stalls or loose boxes using individual portable milking machines.	Milking mares in stalls, using mobile milking units (complexes), which move between stalls during milking. Milking mares in stalls or loose boxes using individual portable milking machines.	Milking mares in stalls or loose boxes using individual portable milking machines. Milking mares by hand.	Milking mares in stalls or loose boxes using individual portable milking machines DDA-2M (farm "Shaushen" Zhambyl region). Milking mares by hand (farm "Ertai" in Zhambyl region).
The way of milking mares	Milking without sucking (breeding horse breeds)	Milking with sucking	Milking with sucking	Milking with suction (Farm "Ertai" in the Zhambyl Region)
Production of mare's milk.	Year-round (factory horse breeds), Seasonal	Seasonal	Seasonal	Seasonal (Farm "Ertai" of Zhambyl Region, Farm "Shaushen" of Zhambyl Region).

In the farm "Ertai" of the Zhualyn district, the farm "Shaushen" of Turar Ryskulov district of the Zhambyl region, the analysis of the average capacity and filling of the udder of mares of the Kazakh horses was carried out (Table 5).

Table 5: Average capacity and udder fullness in mares

Farm	n, animals	Average udder capacity $\bar{X} \pm S_{\bar{X}}$, kg	Limit : min-max	δ	Cv, %	Average milk yield per milking	Udder filling V %
Ertai	65	2.21 ±0.03	0.7-2.8	0.39	22.5	0.8	43.6
Shaushen	310	2.73 ±0.04	1.5-4.1	0.61	19.3	1.27	48.8

Note: The farm "Ertai" practices hand milking; the farm "Shaushen" practices machine milking

The conducted studies have established that with manual milking, the udder filling is 5.2% lower compared to machine milking. With machine milking, the average udder capacity is 0.52 kg (23.5%) higher compared to manual milking. With machine milking, the average milk yield per milking is 0.47 kg (58.8%) significantly higher compared to manual milking.

Table 6: Variability of milk volume in different fractions of one-time milk yield of Kazakh mares, kg

Milk yield fraction	n, animals	$\bar{X} \pm S_{\bar{X}}$	Limit: min-max	δ	Cv
Cisternal	40	0.32 ±0.05	0.05-2.65	0.27	112.9
Alveolar	40	1.45 ±0.12	0.35-3.25	0.63	55.4
Milk yield in general	40	1.77 ±0.18	0.41-3.35	0.71	62.5

The conducted studies showed that the volume of the cisternal fraction of milk varies significantly from 0.05 to 2.65 kg. The coefficient of variability of the cisternal fraction of milk 2.03 times higher compared to the alveolar fraction of milk (Table 6).

Conclusion

When designing kumiss farms in the Russian Federation, Mongolia and the People's Republic of China, the stable sections are predominantly stall and group. The maintenance of mares is tethered and loose, milking of mares is carried out in stalls with mobile milking units.

It is recommended to design mixed stable sections in kumiss farms (when part of the livestock is kept in stalls, and the other part - in group sections). When using milking units, it is necessary to introduce loose housing for mares of domestic breeds (Kazakh, Jabe, Kushumskaya and Mugalzharskaya). Milking with sucking, that is, the foal participates in the milking process, is practiced using DDA-2M milking units. It is recommended to produce mare's milk seasonally, and with a livestock of over 200 mares, all year round. Gradually introduce machine milking of mares in medium-sized kumiss farms. To design kumiss farms with dairy mares, special attention must be paid to the assessment and selection of morphofunctional parameters of the udder.

The average udder capacity of Kazakh mares was 2.21 kg when milked by hand and 2.73 kg when milked by machine. The maximum udder capacity was 2.8 kg when milked by hand and 4.1 kg when milked by machine.

A single milk yield during the milk removal from the udder of Kazakh mares is divided into two fractions (cisternal and alveolar). There is a latent period between the start of milk removal of these fractions. The duration of the latent period varied from 12 to 58 seconds, with an average value of 28 seconds. The average volume of the cisternal fraction was 18.1%, and the alveolar fraction was 81.9% of a single milk yield. The variability of the cisternal fraction volume was twice as high as the variability of the alveolar fraction.

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Author’s Contributions

Khamit Ablgazinovich Aubakirov: Responsible executor, carried out the experimental part of the research. Contribution to implementation and article preparation.

Dastanbek Asylbekovich Baimukanov: Conceived the research idea; performed data analysis and generalization of results. Contribution to implementation and article preparation.

Dilaram Keudenbaevna Karibayeva, Dauren Maratovich Bekenov, Malika Khabidulaevna Shamekova: Contractors; conducted the experimental research.

Makpal Temirkhanovna Kargaeyeva: Performer; contributed to implementation and article preparation.

Ethics

All principles of scientific ethics were observed during the research work. There is no conflict of interest.

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