Dairy productivity of Kazakh horse mares

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Abstract. The work aimed to establish the influence of udder parameters of Kazakh mares on their formation of dairy productivity and the growth rate of foals during the milk period. The cup-shaped udder is characterized by a large base (the udder circumference at the base is 70.3 cm), the symmetrical arrangement of both udder lobes, with well-developed cylindrical nipples, the nipples are widely spaced between the two lobes. The round shaped udder is instead characterized by conical and short nipples and a smaller udder volume. For four months of lactation, 1051 liters of commercial milk were produced from mares with cup-shaped udder, while 823.6 liters- with round-shaped udder. The observation results showed that foals from mares with the cup-shaped and round – shapedudders on the first day of life were 39.8 and 39.6 kg of live weight, respectively, then after a month, it doubles, reaching 82.5 and 79.5 kg. The highest indicators of absolute gain – 42.7 kg, average daily gain – 1.42 kg, and relative gain – 107.3% were observed in offspring with a cup-shaped udder. In foals delivered from mares with a round-shaped udder, the gain rates (39.9; 1.33 kg and 100.7%, respectively) were slightly lower.

1. Introduction

Currently, on the territory of the Republic of Kazakhstan, horse breeding is considered an important developing sector of productive livestock breeding. A variety of natural and climatic conditions make it possible to develop herd horse breeding all year-round grazing with the effective use of winter grazing, without prejudice to other subsectors of animal husbandry.

The main objective for the development of domestic horse breeding is meat production, however over the past 15 years, dairy has also begun to develop rapidly. The increase in consumer demand for mare's milk and koumiss has become a powerful impetus for the development of a productive horse breeding.

With the development of dairy horse breeding, it becomes necessary to include in the list of selection traits, along with traditional traits, some new ones more related to milk production such as...
morphological parameters of the udder of mares. These morphological parameters will significantly increase the efficiency of selection [1,2].

Dairy productivity is the quantity and quality of milk received from an animal for a certain period. The milking capacity of mares depends on the breed, keeping conditions, the quantity and quality of feed consumed, and other factors [3-5].

Mares with high milking capacity are characterized by certain traits of conformation and constitution. They are wide-bodied, squat, and can recover quickly [6,7].

High-yielding mares, as a rule, came from high-yielding mothers, as well as from dairy quality-tested stud horses. In high-milk animals, the udder is of greater size the nipples are well developed, the milk veins are pronounced [8-10].

In dairy horse breeding, high milk yields are a determining factor in production efficiency. Other important zootechnical parameters of productivity such as live body weight, longevity of economic life span use, fertility of animals contributes to an increase in the efficiency and profitability of horse breeding in general.

Therefore, the study and use of the relationship of dairy productivity of mares with other economic traits are relevant for scientists-breeders and owners of koumiss producing farms.

The main solid components of mare's milk are lactose, proteins, fats, vitamins, enzymes, and minerals [11,12].

The aim and objectives of the research is to establish the influence of the morphometric parameters of the udder of dairy mares of the Kazakh horse on the formation of dairy productivity and the intensity of development of foals during the milk period (from birth to 6 months of age).

2. Methodology

The research was carried out according to the scientific and technical program recommended by the Ministry of Agriculture of the Republic of Kazakhstan ‘Smart Agriculture’ BR10865103 ‘Development and creation of scientifically grounded Smart farms (herd horse breeding, beef cattle breeding) using at least 3 different digital solutions for each area’.

The research was conducted in 2021 in the Republic of Kazakhstan. The works on dairy horse breeding was carried out in the farm ‘Bektube’ of the Zhambyl district, Zhambyl region, where the Kazakh mares of the southern population were studied. In the farm ‘Urker’ of the Moynkum district, Zhambyl region, Kazakh mares of the Jabe type have been selected.

In Taushyk LLP, Tupkaragan district, Mangistau region, the object of the research was the Kazakh horse of the Adai offspring. All experimental work was performed on the territory of the Republic of Kazakhstan, therefore, we used the instructions for bonitation of local breeds of horses and camels [13].

Evaluation and grading of horses were carried out following the set of measurements and tests used to evaluate the local horse breeds [14].

The growth and development of the experimental foals were determined from birth to 6 months of age according to the a standard method [14].

Of the mares that were fertile in March and in the first ten days of April 2021, 20 animals were selected according to the shape and size of the udder. The experimental mares were divided into two groups: cup-shaped and round-shaped udder standard method.

The milking capacity of mares before entering the milking process was roughly determined by the increase in live weight of foals for 1 month of their life. Assuming that 1 kg of live weight gain, a foal needs 10 kg of mother's milk. To determine the daily dairy productivity of mares, the formula of I A Saigin (1965) was used (1):

\[ Y_c = \frac{Y_m \times 24}{T}, \]

where, \( Y_c \) – dairy productivity of mares per day (milked + sucked); \( Y_m \) – actual daily milk yield (marketable), determined by the method of control milking; \( T \) – time spent by mares in milking (in
hours) from the moment of weaning (isolation of foals from mares) to the end of the last milking; 24 – number of hours in a day [14].

The analysis of the research results was carried out with general methods of statistical processing of digital data used in biological research [15].

Mare's milk was examined monthly from the second month of lactation. Research samples of milk were taken during the day from the milking’s sessions and stored at temperature +5 °C.

While the collection of samples, milk was stored at temperature +30 °C.

When determining the chemical composition of milk, standard methods were used [16,17]

The fat content of milk was determined with Master ECO Milkotester device (Milkotester, Bulgaria, 2017). The total protein in milk was determined using AM-2 milk analyzer (SibAgroPribor, Russia, 2017).

The udder shape was determined visually, measuring the length and thickness of the teats with a measuring tape (figure 1).

![Figure 1. Measurement of the length and thickness of the teats of the Kazakh Jabe mare, 7 years old, April 2021.](image)

Cup-shaped - conical teats, widely spaced (18-20 cm), directed downward: each udder lobe is developed evenly (figure 2).

Round-shaped - the nipples are thickened and widely spaced (18-20 cm), directed downward; the udder lobes are developed unevenly, at the base of the pear-shaped form (figure 3).

Flat-shaped - the teats are short, flat and close at the base; the udder lobes are unevenly developed.

Studies of mare's milk samples were carried out according to the following indicators: organoleptic assessment; mass fraction of fat; mass fraction of protein; mass fraction of dry substances; density of milk; the acidity of milk and the degree of purity of milk.
3. Results

Comparative studying of economic and useful traits of horses promotes the right choice of breed for these or those specific conditions. Results provide additional opportunities to increase horse breeding production [18].

The cup-shaped udder is characterized by a large base (the circumference of the udder at the base is 70.3 cm), the symmetrical arrangement of both lobes of the udder, with well-developed cylindrical nipples (the length of which is 4.0 cm, and the girth of 13.1 cm), the nipples are widely spaced between the two lobes of the udder (the distance between the ends of the nipples is 7.2 cm) (table 1).

Table 1. Morphometric parameters of the udder of Kazakh horse mares (n=10, \( \Sigma n=20 \)).

| Groups of animals | Udder shape | nipple length | girth of nipples at the base | distance between the ends of the nipples | midline udder length | girth of the udder at the base | n |
|-------------------|-------------|---------------|----------------------------|----------------------------------------|---------------------|-------------------------------|----|
| I                 | Cup         | 4.0±0.5       | 13.1±0.7                   | 7.2±0.6                                | 25.4±1.8            | 70.3±2.1                      | 10 |
| II                | Round       | 3.5±0.4       | 11.4±0.6                   | 7.2±0.4                                | 23.5±1.5            | 64.4±2.5                      | 10 |

Gross productivity is an indicator of the physiological capacity of an animal, depending primarily on genotypic factors as such breed, individual characteristics, etc. However, productivity depends not only on genotype, but also on factors, such as technology, mode and frequency of milking [19,20].

Mares with a round-shaped udder are characterized by conical and short nipples (length - 3.5 cm, girth - 11.4 cm) and a smaller udder volume (udder circumference at the base - 64.4 cm).
It was found that the highest peak of commercial dairy productivity per day and month in groups I and II of animals is observed in the 2nd and 3rd months of milking (9.2; 9.0 and 7.2; 6.9 liters, respectively) (table 2).

In the following months, a gradual decline in milk yield is observed in both groups I and II of animals (8.0 and 6.0 liters, respectively). In general, in mares with a cup-shaped udder, the maximum milk yield is observed in all periods of the experiment, in comparison with the group with a round shapedudder. For four months of lactation, 1051 liters of commercial milk, rounded 823.6 liters, were produced from mares with a cup-shaped udder.

Table 2. Marketable dairy productivity of experimental mares’ milk at a 5-fold frequency of milking (n=3, \(\sum n=6\)).

| Groups of animals | Dairy productivity | Months of lactation | Total for 4 months |
|-------------------|--------------------|---------------------|-------------------|
|                   | Marketable milk    | I       | II      | III     | IV      |                  |
| I                 | marketable milk    | 8.0±0.2 | 9.2±0.3 | 9.0±0.3 | 8.0±0.2 | 1051.0           |
|                   | yield per day      |         |         |         |         |                  |
|                   | per month          | 248     | 276     | 279.0   | 248     |                   |
| II                | marketable milk    | 6.7±0.2 | 7.2±0.1 | 6.9±0.3 | 6.0±0.1 | 823.6            |
|                   | yield per day      |         |         |         |         |                  |
|                   | per month          | 207.7   | 216.0   | 213.9   | 186.0   |                   |

In Kazakhstan-horse breeding, the state of fatness of animals before wintering is very important. The more the young stock will gain weight and strength the higher will be their ability to successfully overcoming wintering. Therefore, we studied the rate of gain in live weight of foals from milking mares.

How much the young stock will gain weight and get stronger depends on the ability to grow up and the success of overcoming wintering. Therefore, we studied the rate of gain in live weight of foals from milking mares.

It was found that the rate of increase in live weight of foals in the first months of life is rather high (table 3).

Table 3. Gain rates of live weight of foals from mares with different udder shapes.

| Traits                        | Udder shape | Cup                  | Round                |
|-------------------------------|-------------|----------------------|----------------------|
| Age of foals at birth         | 1 month     | 3 months            | 6 months (October)  |
| Live weight, kg               | 39.8±0.5    | 82.5±0.9            | 130.5±1.3           | 180.0±1.8          |
| absolute gain, kg             | -           | 42.7                | 48.0                | 49.5              |
| average daily gain, kg        | -           | 1.42                | 0.789               | 0.538             |
| relative growth,%             | -           | 107.3               | 58.2                | 37.9              |
| Age of foals at birth         | 1 month     | 3 months            | 6 months (October)  |
| Live weight, kg               | 39.6±0.7    | 79.5±0.8            | 123.3±1.5           | 165.4±1.5         |
| absolute gain, kg             | -           | 39.9                | 43.8                | 42.1              |
| average daily gain, kg        | -           | 1.33                | 0.718               | 0.457             |
| relative growth,%             | -           | 100.7               | 55.1                | 34.1              |

The observation results showed that in foals from mares with cup-shaped and round-shapedudders on the first day of life were 39.8 and 39.6 kg, respectively, then after a month it doubles, reaching 82.5 and 79.5 kg. The highest indicators of absolute gain - 42.7 kg, average daily gain - 1.42 kg, and relative gain - 107.3% were observed in the offspring of animals with a cup-shaped udder. In foals obtained from mares with a round-shapedudder, the growth rates (39.9 kg; 1.33 kg and 100.7%,
respectively) were slightly lower. The high gain rates of foals in the first months of life are explained by their abundant supply of nutrients with their mother's milk.

In the subsequent months, the rate of the foal live weight gain decreases, since such periods coincide with the milking of mares and therefore an insufficient consumption of mother's milk.

By 6 months of age (October), the average live weight of the offspring of mares with a round-shaped udder was 165.4 kg, and that of the offspring of mares with a cup-shaped udder was 180.0 kg, which is 14.6 kg more than the former.

In previous studies (2020), the average live weight of young animals of different dates of birth with the free range animals was studied. So, the average live weight of young animals of different dates of birth (March and the first ten days of April) by October was in the range of 190-194 kg.

If these data are taken as the maximum indicators of young animals and compared with the data of the current year's experience, then it can be seen that the offspring of animals with a cup-shaped udder by October had 10-14 kg, and with a round-shaped udder was 25-29 kg less than live weight. In general, young stock from mares with a cupped-shaped udder had a live weight within the average indicator, and with a round-shaped udder, it was significantly lower.

The actual task of horse breeding farms engaged in milk/milk and meat horse breeding is to optimize the organization of labor and technological processes, combining the production of kumis with the breeding of young animals. This will allow to increase the herd with young high-milk mares and ensure good gains in young stock.

Proceeding from this, the timing of the milking of Kazakh horse mares was carried out. Milking of mares began at 6 a.m. separating their foals according to the following daily routine (Table 4).

| Name of works                          | Start  | Finish | Duration, hours |
|---------------------------------------|--------|--------|-----------------|
| Suckling of foals                     | 6-00   | 6-10   | 0-10            |
| Watering and grazing of mares         | 6-10   | 8-00   | 1-50            |
| First milking                         | 8-00   | 80-30  | 0-30            |
| Grazing                               | 8-30   | 10-30  | 2-00            |
| Second milking                        | 10-30  | 11-00  | 0-30            |
| Grazing                               | 11-00  | 13-00  | 2-00            |
| Third milking                         | 13-00  | 13-30  | 0-30            |
| Grazing                               | 13-30  | 15-30  | 2-00            |
| Fourth milking                        | 15-30  | 16-00  | 0-30            |
| Grazing                               | 16-00  | 18-00  | 2-00            |
| Fifth milking                         | 18-00  | 18-30  | 0-30            |
| Suckling of foals to the mares and    | 18-30  | 6-00   | 11-30           |
| night grazing                         |        |        |                 |

The mares were milked from 8:30 am to 6:30 pm.

All mares with cup-shaped and round-shaped udders were milked five times - at 8:30, 11:00, 13:30, 16:00, and 18:30. The intervals between milking were 2.5 hours.

All milking mares were fed with concentrate compound feed at the rate of 1 kg per animal and *ad libitum*, hay and water until the need was fully satisfied.

Thus, the grazing of mares was 21 hours 30 minutes per day, including 11 hours 30 minutes with foals. It took 2 hours 30 minutes for 5-fold milking of 30 mares.

Research has been carried out to study the physicochemical parameters of the milk of experimental mares (Table 5).

The research results showed that the fat content in milk was lower in the third month of lactation than in the fifth month. This change is associated with a decrease in milk yield.
Table 5. Physicochemical parameters of experimental mares’ milk.

| Month of lactation | The fat content in the milk of experimental Kazakh mares of the southern population, % | X±m, % | C_v |
|--------------------|-------------------------------------------------------------------------------------|-------|-----|
| III                | 1.38±0.02                                                                         | 12.9  |
| IV                 | 1.45±0.04                                                                         | 7.1   |
| V                  | 1.68±0.06                                                                         | 7.9   |

| Month of lactation | The protein content in the milk of experimental Kazakh mares of the southern population, % | X±m, % | C_v |
|--------------------|-------------------------------------------------------------------------------------|-------|-----|
| III                | 2.30±0.08                                                                         | 7.76  |
| IV                 | 2.23±0.06                                                                         | 7.19  |
| V                  | 2.22±0.04                                                                         | 6.47  |

| Month of lactation | The lactose in the milk of experimental Kazakh mares of the southern population, % | X±m, % | C_v |
|--------------------|-------------------------------------------------------------------------------------|-------|-----|
| III                | 6.24±0.03                                                                         | 2.78  |
| IV                 | 6.42±0.05                                                                         | 2.83  |
| V                  | 6.11±0.04                                                                         | 3.27  |

| Month of lactation | The fat content in the milk of experimental Kazakh mares of the Adai offspring, % | X±m, % | C_v |
|--------------------|----------------------------------------------------------------------------------|-------|-----|
| III                | 1.29±0.03                                                                         | 9.5   |
| IV                 | 1.34±0.04                                                                         | 9.9   |
| V                  | 1.58±0.04                                                                         | 8.1   |

| Month of lactation | The protein content in the milk of experimental Kazakh mares of the Adai offspring, % | X±m, % | C_v |
|--------------------|----------------------------------------------------------------------------------|-------|-----|
| III                | 2.29±0.06                                                                         | 8.60  |
| IV                 | 2.26±0.05                                                                         | 7.62  |
| V                  | 2.21±0.05                                                                         | 7.48  |

| Month of lactation | The lactose in the milk of experimental Kazakh mares of the Adai offspring, % | X±m, % | C_v |
|--------------------|----------------------------------------------------------------------------------|-------|-----|
| III                | 6.21±0.04                                                                         | 2.05  |
| IV                 | 6.37±0.03                                                                         | 1.60  |
| V                  | 6.08±0.06                                                                         | 3.20  |

| Month of lactation | The fat content in the milk of experimental Kazakh mares of Jabe type, % | X±m, % | C_v |
|--------------------|--------------------------------------------------------------------------|-------|-----|
| III                | 1.36±0.03                                                                 | 12.8  |
| IV                 | 1.43±0.04                                                                 | 7.3   |
| V                  | 1.65±0.03                                                                 | 8.1   |

| Month of lactation | The protein content in the milk of experimental Kazakh mares of Jabe type, % | X±m, % | C_v |
|--------------------|--------------------------------------------------------------------------|-------|-----|
| III                | 2.23±0.05                                                                 | 7.78  |
| IV                 | 2.20±0.05                                                                 | 7.05  |
| V                  | 2.18±0.04                                                                 | 6.42  |

| Month of lactation | The lactose in the milk of experimental Kazakh mares of Jabe type, % | X±m, % | C_v |
|--------------------|--------------------------------------------------------------------------|-------|-----|
| III                | 6.13±0.05                                                                 | 2.80  |
| IV                 | 6.24±0.06                                                                 | 2.82  |
| V                  | 5.96±0.06                                                                 | 3.27  |
As you can see, from the analysis on the fat content, superiority is observed in the Kazakh mares of the southern population. The lowest rates were recorded in mares of Adai offspring. Average values were noted in mares of the Jabe type.

The mass fraction of protein is an important parameter for the chemical composition of mare's milk. It was found that in all experimental groups the maximum protein content in milk was recorded in the summer, and the minimum in the fall. This is due to a change in pastures and the intensity of fattening animals in the fall. During the entire observation period, the superiority was on the side of the Kazakh mares of the southern population in terms of this indicator. The intermediate position was occupied by the Kazakh horses of the Adai offspring. The minimum values were established in the milk of Kazakh mares of the Jabe type.

One of the important parameters of mare's milk, which is taken into account in the industrial production of mare's milk, is the content of milk sugar (lactose). The high lactose content in all groups of experimental animals was noted in the fourth month of lactation. In terms of the amount of lactose for the entire observation period, the superiority was in the mares of the Kazakh breed of the southern population. The mares from the group of Kazakh horses of the Jabe type had the smallest indicators in terms of lactose content.

The horse livestock of the rural farms in the southern region of Kazakhstan is mainly found in steppe pastures (figure 4).

![Figure 4. The horse livestock is mainly found in steppe pastures. Kazakh Jabe mares in a spring pasture. May 2020.](image)

In winter, under, horses are fed with hay and, if necessary, with concentrated feed. In the spring, grazing began from pastures located near the farm where wintering took place; as the warming began, the herd grazed gradually in more remote areas. The maximum grazing distance from the farm base was in the summer during the milking period - 5-10 km. In the morning, the herd approached the base.

During the experiment, the tested mares were in the same herd and kept in the same conditions. In addition to their diet, they were given saltlick.

During the daytime milking period, the foals were separated from their mothers and kept in specially equipped pens, and provided with freshly cut pasture grass, water, concentrated, and mineral supplementary feeding. At the end of milking, the foals were released to the pasture with their mothers until the next morning.

Currently, the development of horse breeding in the Republic of Kazakhstan is not possible without the introduction of digital information technologies that facilitate the classic interaction 'man-machine-horse'.
The introduction of digital technologies in horse breeding will create a basis for the accurate management of productive horse breeding by, keeping a strict record of the breeding stock and their progeny.

The adoption of digital technology in horse breeding and the control of production processes will allow, the targeted use of available resources ensuring a reduction of harmful impacts on the environment in the production of industry-specific horse breeding products.

It is planned to adopt digital horse recording systems to better control horse movements. Horse farm owners will be able to use the information data to monitor the location, well-being, and health of their existing horse herds. Most importantly, it will be possible to reliably identify sick horses, and thereby take rapid treatment measures and plan preventive measures.

For the first time, advanced foreign information technologies will be used in the creation of demonstrative smart horse breeding farms for the production of products with minimal costs and high added value. The domestic food industry will learn effective technologies for the production of mare's milk, koumiss, and other fermented milk products with high export potential. In scientific terms, transfer information technologies will be improved and adapted to control the movement of horses and in the production of mare's milk and koumiss from domestic horse breeds, taking into account the regional characteristics of Kazakhstan in the world market.

4. Conclusions

The impact of morphometric parameters of the udder of Kazakh mares on the formation of dairy productivity and the development intensity of foals during the milk period (from birth to 6 months of age) has been established. The highest indices of absolute gain, average daily gain and relative gain were noted in the offspring of animals with a cup-shaped udder. In foals obtained from mares with a round-shaped udder, the growth rates were slightly lower.

The research on the structure of the cup-shaped udder of mares showed that it is characterized by a large base - a circumference at the base of 70.3 cm, a symmetrical arrangement of both lobes of the udder with well-developed cylindrical nipples - the length of which is 4.0 cm, the girth is 13.1 cm, the distance between nipples 7.2 cm. Nipples of the udder are rounded, conical, the length of which is 3.5 cm, and the girth of 11.4 cm and a smaller volume is 64.4 cm.

The highest peak of commercial dairy productivity in milking mares is observed at the 2nd and 3rd months of milking (9.2; 9.0 and 7.2; 6.9 liters, respectively). In mares with a cup-shaped udder in all periods of the experiment, a greater milk yield is observed than in mares with a round-shaped udder. Thus, according to the results of four months of milking, mares with a cup-shaped udder produce 1051.0 liters of commercial milk, which is 227.4 liters more than their contemporaries with a round-shaped udder.

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