ISSN 1068-3674, Russian Agricultural Sciences, 2023, Vol. 49, No. 4, pp. 435–440. © Allerton Press, Inc., 2023.
Russian Text © The Author(s), 2023, published in Rossiiskaya Sel'skokhozyaistvennaya Nauka, 2023, No. 3, pp. 63–66.

ANIMAL SCIENCE
AND VETERINARY MEDICINE

Genetic Parameters for Milk Production of Female Camels of the Kazakhstan Population

D. A. Baimukanov[a,*], O. A. Alikhanov[b], S. D. Mongush[c], Yu. A. Yuldashbayev[d], and V. A. Demin[d]

[a] *Science and Production Center for Animal Husbandry and Veterinary, LLP, Astana, 010000 (Z10P6B8) Kazakhstan*
[b] *Auezov South Kazakhstan State University, Shymkent, 130050 Kazakhstan*
[c] *Tuva State University, Kyzyl, 607000 Russia*
[d] *TSKhA Russian State Agricultural University–Moscow Timiryazev Agricultural Academy, Moscow, 127550 Russia*
**e-mail: dbaimukanov@mail.ru*

Received March 6, 2023; revised March 29, 2023; accepted April 25, 2023

Abstract—Surveys have been performed in order to determine the key genetic parameters (variability, heritability, and repeatability) of milk production traits of camels of different breeds in current livestock populations to optimize effective selection. The research objects are the camels of the Kazakh Bactrian breed (200 head), the Turkmen Arvana dromedary breed (120 head), the Kazakh dromedary breed (120 head) reared in South and Southeast Kazakhstan, and the Mongolian Bactrian breed (30 head) of the Tuvan population reared in the forest-steppe and dry-steppe zones of the Republic of Tuva in the Russian Federation. The studied female camel age defined focused on lactation records per productive lifespan was in the range of 1 to 12 lactation cycles. The surveys were carried out in 2020–2022. Female camels of the Kazakh Bactrian, Turkmen Arvana dromedary, Kazakh dromedary, and Tuvan population Mongolian Bactrian breeds are capable to produce 1111.2 ± 45.1 kg, 1588.8 ± 58.4 kg, 1870.0 ± 47.5 kg, and 933.5 ± 29.8 kg 4%-fat milk over 210-day lactation periods, respectively. Coefficients of variability in the milk yield, fat content, protein content, fat yield, and protein yield comprised 19.7–35.9, 6.2–9.9, 3.9–7.2, 22.2–41.9, and 19.5–36.9%, respectively. Coefficients of heritability of the studied breeding traits had the mean range expressed as h^2 – 0.25–0.55. Coefficients of repeatability of milk production for the first to second lactation cycles, mass fractions of milk fat and protein, milk fat yield, and milk protein yield comprised 0.65–0.82, 0.58–0.85 and 0.59–0.88, 0.75–0.82, and 0.72–0.83, respectively. The coefficient of correlation between the values for milk production of female camels of first foaling over the 105- and 210-day lactation periods ($P < 0.001$) varied from +0.42 to +0.78, which indicates the reliability of the milk production forecast based on the assessment data over the first 105 days of lactation.

Keywords: camels (Camelus bactrianus, Camelus dromedarius), milk yield, fat, protein, heritability, variability, repeatability

DOI: 10.3103/S1068367423040055

INTRODUCTION

Camel milk is more efficient than cow milk. In addition, it is rather similar to human milk in its nutritional value. It is characterized by high concentrations of biologically active compounds required for a human. However, camel milk products remain narrowly distributed, despite the great nutritional value and benefits for the health of the population [1]. Natural camel milk contains many common salts, calcium, protective proteins, and elements, such as iron, copper, and zinc. Unique composition of camel milk makes it an excellent food product for people living in regions (dry and semidry environments), where plants (fruit and vegetables) can be rarely found. Scientific understanding of the gross composition data on camel milk may motivate the consumers to include this product into their diet and, therefore, to boost camel milk production capacity and its use as a component in a human diet [2].

The intensity of camel milk secretion is related to milk accumulation and ejection from the mammary glands, because the udder capacity in female camels, similar to that in mares, is rather less than the cow udder capacity. Therefore, the camel milk production is directly connected with the udder milk storage capacity and its milk-producing ability [3]. In addition, the information on the production profile in the total population are required to build camel breeding herds representing specific production systems [4]. As stated above, it is necessary to study the genetic parameters focusing on the breeding traits of camels reared in the Republic of Kazakhstan and the Republic of Tuva, Russian Federation.

The objective of the survey is to determine the key genetic parameters (variability, heritability, and repeatability) of milk production traits of camels of different breeds in current populations to optimize effective selection.

EXPERIMENTAL

The research objects are the current camel populations of the Kazakh Bactrian breed (200 head), the Turkmen Arvana dromedary breed (120 head), the Kazakh dromedary breed (120 head) reared in South and Southeast Kazakhstan, and the Mongolian Bactrian breed (30 head) of Tuvan population reared in the forest-steppe and dry-steppe zones of the Republic of Tuva in the Russian Federation. The studied female camel age defined focused on lactation records per productive lifespan was in the range of 1 to 12 lactation cycles.

The surveys were carried out in 2020–2022. The camels of the Kazakh Bactrian population of 200 head, the Turkmen-dromedary breed population of 120 head, the Kazakh dromedary breed population of 120 head, and the Mongolian Bactrian breed of the Tuvan population of 30 head were studied.

The surveys used a complex of special research methods to assess milk production and determine the liveweight (kg) and to estimate the milk yield over a 210-day lactation period (kg), the mass fractions of milk fat and protein (%), the milk fat and protein yields (kg), the milkability index, and the lactation index.

The milkability index characterizing the milk production per 100 kg of liveweight was estimated with the following formula:

$$MI = LMI/LW, \quad (1)$$

where MI is milkability index, LMI is milk yield over a lactation period, kg, and LW is female camel body liveweight, kg.

The lactation index representing the total amount of fat and protein in milk was estimated with the following formula:

$$LI = MFY + MPY, \quad (2)$$

where LI is lactation index, MFY is milk fat yield, kg, and MPY is milk protein yield, kg.

Milk production performance of female camels was assessed as the total milk production estimated based on the monthly milking control solutions. The common methodical approaches were involved to assess the milk production performance parameter for female camels. Milk yield records were performed based on the control milking solutions, which were deployed twice monthly. Daily milk production performance was estimated with the formula

$$PPD = MPD/t \times 24. \quad (3)$$

where PPD is milk production performance per female camel per day, kg, MPD is actual milk production per day estimated with the control milking method, kg, t is time spent for a lactation cycle between the foal weaning date and the end of last milking, h, and 24 is 24 h in a day.

The dried skimmed milk powder and lactose contents were measured with the "Klever-1M" device. The milk fat and crude protein contents were measured with the *Milkotester* device and the AM-2 analyzer, respectively. The maximum udder milk-storage capacity was estimated with the method developed by E.D. Chirgin (5). In order to perform it, female camels were milked after last milking followed by one missed milking event, i.e., the period between them was specially delayed for 6 h so that the udder could be filled with milk. The assessment was performed in the second to third month of a lactation cycle, when the udder capacity of female camels was maximal, according to the instructions for bonitation of Bactrian and dromedary breed camels, based on the breeding principles and concepts (Astana, 2014). The surveys were carried out according to the functional methodologies developed for planning and monitoring the zootechnical experiments.

Coefficients of variability, hereditary, and repeatability in correlated traits were estimated with the common statistical methods used in zootechnics. Hereditary was established with the coefficients of correlation between the mother milk production performance during peak lactation and the daughter milk production performance in the first lactation cycle. Milk trait repeatability was determined based on the correlation between the values for parameters across the adjacent (first and second) lactation cycles.

RESULTS AND DISCUSSION

Among the considered genotypes, the animals of the Kazakh dromedary breed (589.2 kg) were characterized by the greatest liveweight, while the lightest liveweight was recorded in camels of the Mongolian Bactrian breed of the Tuvan population (485.1 kg). In addition, the values for 4%-fat milk yields over a 210-day lactation period were distributed in a similar way, comprising 1870.0 ± 47.5 kg and 933.5 ± 29.8 kg, respectively (Table 1).

Among the studied production traits, the values for milk yields over a 210-day first-lactation period (Table 2) were characterized by high variability (CV = 19.7–35.9%), i.e., breeding in this way tends to be most effective. Variability in the mass fractions of fat and protein in milk of female camels of first foaling was hardly more than a 10% difference, while variabilities in the fat and protein contents comprised 6.2–9.9 and 3.9–7.2%, respectively, which can indicate the relative stability of these traits. Therefore, the potential effects of selection for milk fat and protein contents may only

Table 1. Selection parameters of female camels

Trait under study	Breed			
	Kazakh Bactrian ($n = 200$)	Turkmen Arvana dromedary ($n = 120$)	Kazakh dromedary ($n = 120$)	Mongolian Bactrian of Tuvan camel population ($n = 30$)
Liveweight, kg	575.4 ± 25.6	534.7 ± 18.3	589.2 ± 22.6	485.1 ± 12.9
Milk yield per 210 days of lactation, kg	793.7 ± 33.8	1925.9 ± 60.1	1739.5 ± 41.6	691.5 ± 24.2
Mass fraction, %:				
milk fat	5.6 ± 0.08	3.3 ± 0.06	4.3 ± 0.07	5.4 ± 0.09
milk protein	3.9 ± 0.05	3.7 ± 0.04	3.9 ± 0.04	3.8 ± 0.05
4%-fat milk yield, kg	1111.2 ± 45.1	1588.8 ± 58.4	1870.0 ± 47.5	933.5 ± 29.8
Milk fat, kg	44.4 ± 1.2	63.5 ± 3.1	74.8 ± 1.9	37.3 ± 1.1
Milk protein, kg	31.0 ± 0.9	71.2 ± 1.7	67.8 ± 1.3	26.3 ± 0.9
Coefficient of milkability				
at initial milk fat content	1.38	3.60	2.95	1.42
at basal milk fat percentage (4%)	1.93	2.97	3.17	1.92
Lactation indicator, kg	75.4	134.7	142.6	63.6

occur over long periods. The variability coefficients of milk fat and protein yields make up 22.2–41.9 and 19.5–36.9%, respectively.

A heritability coefficient is the main genetic parameter, which reflects the proportion of hereditary variability in a trait to serve as a breeding indicator of selection for production parameters. Its values for the studied breeding traits have the means expressed as $h^2 = 0.25–0.55$ for dairy female camels, which can indicate the stability of inheritance of production traits from mothers to their offspring. The value of this parameter generally indicates the potential for effective selection of breeding stock for milk production and milk quality parameters, including milk mass fractions of fat and protein.

Selection efficiency depends greatly on repeatability of a breeding trait. The survey-based data indicated high repeatabilities of all the production traits. Repeatability coefficients for the milk yield over the first and second lactation periods, the milk fat mass fraction, the milk protein mass fraction, the milk fat yield, and the milk protein yield comprised 0.65–0.82, 0.58–0.85, 0.59–0.88, 0.75–0.82, and 0.72–0.83, respectively.

A coefficient of correlation between the values for milk production of female camels over 105 days and 210 days of a lactation cycle after first foaling ($p < 0.001$) varies from +0.42 to +0.78. It indicates the probability to make reliable predictions for milk production of female camels after first foaling for 210 days of lactation based on the assessment data on their milk production over the first 105 days of lactation (Table 3).

When selecting dairy female camels for several breeding traits, it is recommended to consider the types of relationships between them. It has been proven that the milk fat and protein contents tend to reduce though at different rates with selection focused on increasing the absolute milk yield. The milk fat content tends to reduce to a greater extent, while the milk protein content is expected to decrease insignificantly. However, a stable positive relationship between the mass fat and protein fractions in milk of dairy female camels expressed as $r = +0.17$ and $r = +0.22$, respectively, was revealed. The most reliable ($p \leq 0.001$) positive ($r = 0.91–0.96$) relationship between the milk yield and the milk fat and protein yields was found (Table 4).

A high correlation between the maximum udder milk-storage capacity in female camels and the estimated daily milk yield (+0.71 ± 0.02) and the average per record milk yield (+0.85 ± 0.03) was revealed. The survey-based datasets can prove a close direct relationship between the productive performance and the udder milk-storage capacity in female camels.

The udder milk-storage capacity in 70% of the Kazakh and Mongolian Bactrian female camel populations comprised 1.00–1.69 L. With respect to the same portion of animals of the Turkmen Arvana dromedary livestock populations, the udder capacity was measured as 2.0 to 2.69 L. In 80% of the Kazakh dromedary female camels, the udder had a capacity of 1.7–2.49 L (Table 5).

Table 2. Genetic parameters for camel milk productivity

Trait	Genetic parameter	Breed			
		Kazakh Bactrian (n = 200)	Turkmen Arvana dromedary (n = 120)	Kazakh dromedary (n = 120)	Mongolian Bactrian of Tuvan camel population (n = 30)
Milk yield per 210 days of lactation, kg	Coefficient of variability (CV, %)	31.5	19.7	24.2	35.9
	Coefficient of hereditary (h^2)	0.42	0.25	0.31	0.47
	Coefficient of repeatability (rs) for 1–2 lactation cycles	0.82	0.65	0.74	0.78
Milk fat, %	Coefficient of variability (CV, %)	8.7	6.2	9.1	9.9
	Coefficient of hereditary (h^2)	0.39	0.28	0.31	0.42
	Coefficient of repeatability (rs) for 1–2 lactation cycles	0.73	0.58	0.65	0.85
Milk protein, %	Coefficient of variability (CV, %)	5.4	3.9	4.8	7.2
	Coefficient of hereditary (h^2)	0.35	0.23	0.27	0.46
	Coefficient of repeatability (rs) for 1–2 lactation cycles	0.72	0.59	0.69	0.88
Milk fat, kg	Coefficient of variability (CV, %)	32.4	31.3	22.2	41.9
	Coefficient of hereditary (h^2)	0.38	0.26	0.33	0.51
	Coefficient of repeatability (rs) for 1–2 lactation cycles	0.82	0.75	0.84	0.78
Milk protein, kg	Coefficient of variability (CV, %)	31.8	19.5	21.9	39.6
	Coefficient of hereditary (h^2)	0.41	0.27	0.32	0.55
	Coefficient of repeatability (rs) for 1–2 lactation cycles	0.79	0.72	0.81	0.83

Table 3. Coefficient of correlation between milk production traits for first 105 days and 210 days of lactation

Trait	Breed			
	Kazakh Bactrian (n = 200)	Turkmen Arvana dromedary (n = 120)	Kazakh dromedary (n = 120)	Mongolian Bactrian of Tuvan camel population (n = 30)
Milk production	+0.61	+0.71*	+0.75*	+0.58
Mass fraction of milk fat	+0.49	+0.53	+0.57*	+0.43
Milk fat yield	+0.67	+0.73*	+0.78*	+0.59
Mass fraction of milk protein	+0.46	+0.58*	+0.56	+0.42
Milk protein yield	+0.62	+0.72	+0.77*	+0.55

*$p < 0.001$

The Arvana female camels were generally different in higher milk yields at a relatively low milk fat content when compared to that in the Kazakh Bactrian. The analysis of the lactation curves for milk production in female camels showed that the highest daily milk yields in the specimens of different genotypes, reared in different environments, were recorded within the second to third month of lactation. The average milk production of the studied camel livestock populations over 7 months of lactation comprised 1089.9 kg milk with a fat content of 5.1%.

The correlation research can provide the opportunity to improve the efficiency of selection for a production trait through the other side parameter records

Table 4. Correlation coefficient for production performance of female camels of the first foaling cycle

Traits under study	Camel breed			
	Kazakh Bactrian (n = 200)	Turkmen Arvana dromedary (n = 120)	Kazakh dromedary (n = 120)	Mongolian Bactrian of Tuvan camel population (n = 30)
Milk yield – Mass fat fraction	–0.12*	–0.09*	–0.11*	–0.15*
Milk yield – Mass protein fraction	–0.05*	–0.03*	–0.03*	–0.04*
Mass fat fraction – Mass protein fraction	0.22*	0.19*	0.21*	0.17*
Milk yield – Milk fat yield	0.94*	0.95*	0.95*	0.91*
Milk yield – Milk protein yield	0.95*	0.96*	0.96*	0.92*

*$p < 0.001$

Table 5. Monitoring of relationships between the udder volume and their milk production and productive lifespan

Item	Physiological capacity of camel udder, L					
	1.00...1.49	1.50...1.69	1.70...1.99	2.00...2.24	2.24...2.49	2.50...2.69
Kazakh Bactrian (n = 50)						
Livestock, heads	20	15	10	5	–	–
Productive lifespan, lactation cycles	8.0	8.0	7	7	–	–
Lifetime milk production, kg	10800	12280	12740	15750	–	–
Average milk yield per lactation, kg	1350	1535	1820	2250	–	–
Turkmen dromedary (n = 50)						
Livestock, heads	–	5	5	15	15	10
Productive lifespan, lactation cycles	–	8.0	8.0	7.0	7.0	6.0
Lifetime milk production, kg	–	25600	27120	26740	29400	27600
Average milk yield per lactation, kg	–	3200	3390	3820	4200	4600
Kazakh dromedary (n = 50)						
Livestock, heads	–	5	15	15	10	5
Productive lifespan, lactation cycles	–	8.0	8.0	7.0	6.0	5.0
Lifetime milk production, kg	–	20000	22800	22050	21000	21000
Average milk yield per lactation, kg	–	2500	2850	3150	3500	4200
Mongolian Bactrian of Tuvan camel population (n = 50)						
Livestock, heads	20	15	10	–	–	–
Productive lifespan, lactation cycles	8.0	8.0	7	–	–	–
Lifetime milk production, kg	4400	6240	9940	–	–	–
Average milk yield per lactation, kg	550	780	1420	–	–	–

and to exclude the undesirable consequences of ineffective one-sided selection for a single trait.

CONCLUSIONS

The coefficient of correlation between the values for milk production of female camels of first foaling for 105 days and 210 days of lactation ($P < 0.001$) varied from +0.42 to +0.78, which indicates the reliability of the milk production forecast based on the assessment data for the first 105 days of lactation. High repeatability in milk yields between the lactation cycles may serve as justification for improving the production performance of a dairy camel herd based on the evaluation of female camels of first foaling over 210 days of lactation. The target selection of camels for this trait as herd replacements is based on their potential to contribute to the accelerated genetic progress. The fat content tends to decrease in the milk produced by the female camels as their milk yields increase.

COMPLIANCE WITH ETHICAL STANDARDS

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

STATEMENT ON THE WELFARE OF ANIMALS

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. The article does not concern any researches using animals as objects.

REFERENCES

1. Benmeziane-Derradji, F., Evaluation of camel milk: gross composition-a scientific overview, *Trop. Anim. Health Prod.*, 2021, vol. 53, no. 2, p. 308. https://link.springer.com/article/10.1007/s11250–021–02689–0. Cited January 15, 2023. https://doi.org/10.1007/s11250–021–02689–0
2. Baimukanov, A.D., Yuldashbaev, Yu.A., Kargaeva, M.T., et al., Productive profile of the breeding stock of camels of the Kazakh bactrian breed of the Balkhash type, *Zootekhniya*, 2022, no. 10, pp. 23–25. https://doi.org/10.25708/ZT.2022.55.72.006
3. Baimukanov, A., Morphofunctional features of the udder of camels, in *Verblyudovodstvo v Kazakhstane* (Camel Breeding in Kazakhstan), Almaty: Bastau, 1995, no. 1, pp. 7–11.
4. Ho, T.M., Zou, Z., and Bansal, N., Camel milk: A review of its nutritional value, heat stability, and potential food products, *Food Res. Int.*, 2022, vol. 153, p. 110870. https://www.sciencedirect.com/science/article/abs/pii/S0963996921007705?via%3Dihub. Cited January 11, 2023. https://doi.org/10.1016/j.foodres.2021.110870
5. Chirgin, E.D., Capacity of the udder Russian draft breed mares, *Vet. Vrach*, 2015, no. 5, pp. 59–62.

Translated by O. Zhiryakova

SPELL:OK