



DOI 10.32900/2312-8402-2024-132-27-43

UDC 636:12/13.082:575.857(477)

FACTORS INFLUENCE ON THE MILK QUALITY INDICATORS OF NOVOOLEKSANDRIVSKIA HEAVY-DUTY BREED MARES

Aleksii BROVKO, <https://orcid.org/0000-0001-5379-309X>

Iryna TKACHOVA, DAgSc., Senior Researcher

<https://orcid.org/0000-0002-4235-7257>

Galyna PRUSOVA, CandAgSc., Senior Researcher

<https://orcid.org/0000-0002-2604-5720>

Serhii LIUTYKH, CandAgSc., Senior Researcher

<https://orcid.org/0009-0009-8964-442X>

Livestock farming institute of NAAS of Ukraine, Kharkiv, Ukraine

The article presents the results of studies of milk productivity and milk quality of mares of the Novooleksandrivka heavy draft breed. The daily milk yield of mares and milk quality indicators in samples taken in June and August were determined, and it was proven that all indicators vary significantly. It was established that the indicators of dry matter, protein, lactose and dry non-fat milk residue were higher in June, and the protein content, fat-protein ratio, freezing point and somatic cell count were higher in August. Differences in milk quality indicators from the first and second milking were revealed, and a higher content of almost all studied indicators was established in milk samples taken from the first milking in June and August, in August - with a much smaller difference. Significant correlations were found between milk quality indicators - dry matter ($r=0.856$), fat ($r=0.728$), fat-protein ratio ($r=0.861$) in milk samples taken in June and August from the first, second milking and daily milk yield. In milk milked in August, these relationships. In all samples, a negative relationship was established between the amount of milk and the content of somatic cells.

The influence of the lactation period on milk productivity and milk quality indicators of experimental mares was established - the highest daily milk yield, dry matter and fat content in milk were characterized by mares at the lowest lactation periods. The influence of the age of experimental mares on their daily milk yield and milk quality indicators was established, the superiority of mares aged 9-13 years in June ($r=0.431$), and older ones in August ($r=0.352$) was proven in terms of daily milk yield. It was determined that the age of mares affects the duration of their foaling ($r=0.396$). The advantage in daily milk yield of mares with a foaling duration of over 350 days was proven according to the results of control milking in both June and August. In terms of dry matter, fat and fat-protein ratio in milk samples of experimental mares with a foaling duration of over 340 days according to the results of control milking in both June and August, as well as the highest lactose content and freezing point index in samples taken in June and protein - in samples taken in August.

It was established that mares that foaled with foals, with a high degree of probability ($p<0.01$) had a higher daily milk yield, as well as milk yields for the first and second milking, a higher dry matter, fat, fat-protein ratio.

Keywords: horses, mares, Novoaleksandrivka heavy-duty breed, milk productivity, milk quality, influencing factors



ФАКТОРИ ВПЛИВУ НА ПОКАЗНИКИ ЯКОСТІ МОЛОКА КОБИЛ НОВООЛЕКСАНДРІВСЬКОЇ ВАГОВОЗНОЇ ПОРОДИ

Олексій БРОВКО, <https://orcid.org/0000-0001-5379-309X>

Ірина ТКАЧОВА, д. с.-г. н., с. н. с., <https://orcid.org/0000-0002-4235-7257>

Галина ПРУСОВА, к. с.-г. н., старший дослідник,
<https://orcid.org/0000-0002-2604-5720>

Сергій ЛЮТИХ, к. с.-г. н., с. н. с., <https://orcid.org/0009-0009-8964-442X>

Інститут тваринництва НААН, Харків, Україна

У статті викладено результати досліджень молочної продуктивності і якості молока кобил новоолександрівської вагОВОЗНОЇ породи. Визначено добовий надій кобил та показники якості молока у зразках, відібраних у червні та серпні, доведено, що усі показники значно варіюють. Встановлено, що показники вмісту сухої речовини, білку, лактози і сухого знежиреного залишку молока були вищими у червні, а вміст білку, співвідношення жиру і білку, точка замерзання і кількість соматичних клітин – у серпні. Виявлено відмінності показників якості молока від першого і другого доїння, встановлено вищий вміст майже усіх досліджених показників у зразках молока, відібраного від першого доїння у червні і серпні, у серпні – зі значно меншою різницею. Виявлено значні кореляційні зв'язки між показниками якості молока – сухої речовини ($r=0,856$), жиру ($r=0,728$), співвідношенням жиру і білку ($r=0,861$) у зразках молока відібраних у червні і серпні від першого, другого доїння і добовому надої. У молоці, надоєному у серпні, ці зв'язки. В усіх зразках встановлено негативний зв'язок між кількістю молока і вмістом соматичних клітин.

Встановлено вплив терміну лактації на показники молочної продуктивності і якості молока дослідних кобил – найвищим добовим надоєм, вмістом сухої речовини і жиру у молоці характеризувалися кобили на найменших термінах лактації. Встановлено вплив віку дослідних кобил на їх добовий надій і показники якості молока, доведено перевагу за добовим надоєм кобил у віці 9-13 років у червні ($r=0,431$), та старшого віку – у серпні ($r=0,352$). Визначено, що вік кобил впливає на тривалість їх жеребності ($r=0,396$). Доведено перевагу за добовим надоєм кобил з тривалістю жеребності понад 350 діб за результатами контрольного доїння як у червні, так і у серпні. За вмістом сухої речовини, жиру та співвідношення жиру і білка у зразках молока дослідних кобил з тривалістю жеребності понад 340 діб за результатами контрольного доїння як у червні, так і в серпні, а також найвищий вміст лактози і показник точки замерзання у зразках, відібраних у червні та білка – у зразках, відібраних у серпні.

Встановлено, що кобили, які ожеребилися жеребчиками, з високим ступенем вірогідності ($p<0,01$) мали вищий добовий надій, а також надої за перше і друге доїння, вищий вміст сухої речовини, жиру, співвідношення жиру і білку.

Ключові слова: коні, кобили, новоолександрівська вагОВОЗНА порода, молочна продуктивність, якість молока, фактори впливу.

Mares' milk as a food product is traditionally produced in Asian countries: North China, Mongolia, Kazakhstan, Bashkortostan, Kyrgyzstan, Uzbekistan, Buryatia, Kalmykia (Pieszka M., 2016; Blanco-Doval A., 2024). In these countries, mares' milk accounts for more than 8% of total milk production (Gall C. F., 2013), and it is traditionally used for the production of fermented milk drinks (ayran, koumiss, etc.). At the same time, the consumption of mares' milk has spread in recent decades in the



countries of the European Union: France, Belgium, Germany, the Netherlands, Norway, Austria, Hungary, Bulgaria. In European countries, the share of mares' milk in total milk production is only 0.1%, which is about 1300 tons.

Horse breeding is well developed, and productive – in particular, in Kazakhstan, where there are 2,862,600 horses (as of June 1, 2018), while it is reported that the annual increase in the livestock is about 100 heads (Naimanov D. K. et al. 2018). The development of productive horse breeding in Kazakhstan is facilitated by the presence of large areas of natural pastures (in Northern Kazakhstan alone there are 1.5 million hectares). Kazakhstan can be an example of the boundless centuries-old love of the people for horses, as well as the traditional significant demand for koumiss and other horse breeding products, which ensures the development of the horse breeding industry.

More than 30 million people in the world regularly consume mare's milk and its processed products (Doreau M., 2011). Mare's milk has high nutritional value and practically does not contain allergenic proteins, unlike cow's milk. This factor makes it possible to use mares' milk in children's and dietary nutrition (Kunying L., 2024). Organoleptically, mares' and women's milk are very similar, but mares' milk is more transparent, whiter and sweeter due to the higher lactose content. The peculiarities of the morphology of the mammary gland of mares determine the low milk productivity of mares, however, for horses of the Mongolian, Bashkir, Yakut, Kyrgyz, Kazakh (with the Kabyn meat type and Adai breed), Kushum, Mughalzhazhar, and Kustanai breeds, this feature is of selection (Naymanov D. K. et al., 2018). It is known that the highest amount of milk is produced by mares 30-60 days after foaling, when daily milk production can vary from 12 to 15 liters, which is about 21-25% of the foal's body weight (Morresey, P.R., 2012). However, there are more productive breeds: Mughalzhazhar (2200-2500 l of milk per lactation) (Seleuova, 2018), Kushum (2000 l of milk per 3 months of lactation), Jabe (up to 20 l per day) (Naymanov D. K. et al., 2018).

Quite high milk productivity is characteristic of mares of heavy draft breeds, which is due to the greater body weight and intensity of foal development. A unique breed of heavy draft horses, Novoaleksandrivska, has been bred in Ukraine, which is characterized by relatively high milk productivity (2500-3000 kg of milk per lactation). Mares' milk has high nutritional value and practically does not contain allergenic proteins, unlike cow's milk (Reiter, 2023), which determines the relevance of the research. Based on the relevance, the purpose of the study was to determine the quality indicators of milk of mares of the Novoaleksandrivska heavy draft breed.

Materials and methods of research. In the conditions of the branch of the Dibrivsky stud farm No. 62 of the State Enterprise "Equestrianism of Ukraine" of the Poltava region, experiments were conducted in 2024 to study the milk productivity and quality of milk of mares of the Novoaleksandrivka heavy draft breed. 16 healthy mares were selected for the experiment, which successfully foaled healthy foals and produced mature milk. The beginning of milking of the mares took place a month after their foaling. Gross milk collection for the production of koumiss was carried out during May-October. Lactation dates were established according to primary documents, in particular, the data of the foaling-mating record, from which the term of fertilization of each mare, the term of foaling, and the sex of the foal were established. At the end of the season, gross milk yield was determined.

Control milkings were carried out using dual-mode milking machines DDU-2 in June and August. Sanitary and hygienic treatment of udders and teats in mares of all groups was carried out using an antiseptic solution. Mares were milked twice in the morning and evening, milking duration – up to 2 minutes. Milking was carried out in a specially equipped milking shop in separate stalls, foals during milking were in close



visibility of mares, which contributed to the milk ejection reflex and nervous balance of mares and foals. Foals on the day of control milking received the necessary amount of milk through artificial drinking, which was not reflected in their condition and live weight gain. After each milking, the amount of milk in the bucket was measured, the total daily yield was determined as the sum of both milkings per day. For statistical calculations, only the indicator of milked milk (excluding milk consumed by foals) was used.

Milk samples were collected in sterile containers with a preservative. When collecting milk samples, the European requirements of Codex Alimentarius, vol. 13 "Methods of analysis and sampling" and DSTU ISO 707:2002ⁱ Milk and dairy products, instructions for sampling were followed. Samples were collected with a sterile syringe in proportion to the first and second milkings per day, cooled to 10°C and immediately transported to the laboratory in a thermobox. Only milk samples that were visually determined to be whole, clean, and in consistency represented a white liquid with a slight blue tint, without sediment and clots, with a delicate milky odor were analyzed.

The physical and technological properties of milk were studied according to DSTU 8009:2015. Biochemical indicators of milk were determined in a certified laboratory for assessing the quality of livestock products. The chemical composition of milk (fat, protein, lactose, dry matter, protein, dry non-fat milk residue (SNFRM) content in %) and freezing point (°C) were determined according to ISO 9001:2000 instrumentally on the device "Bentley-150" (certificate IDA 0001461-1 dated 16.12.2004). The content of somatic cells (thousands/cm³) was determined according to ISO 9001:2000 instrumentally on the device "Somacount-150" (certificate IDA 0001461-1 dated 16.12.2004).

Daily milk yields and milk quality were determined in June and August, including for the first and second milking per day depending on the lactation period, age of mares, duration of pregnancy, sex of foals.

The relationships between the studied indicators were determined by calculating the correlation coefficient (r).

All experimental studies were conducted in accordance with modern methodological approaches, requirements and standards (DSTU ISO/IEC 17025:2019, 2021), Directive 2010/63/EU (2010), the Procedure for conducting animal experiments in scientific research institutions (Law of Ukraine No. 249, 2012) and in accordance with the Regulations of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (Strasbourg, 1985).

Research results. Analysis of milk productivity based on the results of control milkings of experimental mares showed that the daily milk yield with double milking in June was on average higher by the milking group than in August by 0.381 l (Table 1). at the same time, in both June and August, more milk was obtained from the second milking (by 0.587 l in June and 0.300 l in August). All the studied indicators of daily milk yield are characterized by high coefficients of variation.

A difference was established between the quality indicators of the milk of the studied mares in the samples taken in June and August. Thus, the indicators of dry matter, protein, lactose and SPPW were higher in June, and the protein content (and, accordingly, the ratio of fat to protein), freezing point and the number of somatic cells were higher in August. In general, almost no somatic cells were detected in the milk of mares, which is explained by its high antibacterial properties.

ⁱⁱ DSTU ISO 707:2002 Milk and dairy products. Guidelines for sampling. (2003). Retrieved from https://online.budstandart.com/ua/catalog/doc-page?id_doc=67272



Table 1

Indicators of milk productivity and quality of daily milk yield of mares depending on the month of milking

Milk quality indicators	June				August			
	M±m	Cv, %	min	max	M±m	Cv, %	min	max
Daily milk yield, l	2,78±0,24	34,5	1,6	5,9	2,46±0,21	33,2	1,1	4,9
1st milking	1,10±0,08	28,6	0,5	1,9	1,08±0,13	47,1	0,6	2,7
2nd milking	1,68±0,18	42,8	1,1	4,0	1,38±0,10	28,4	0,4	2,2
Content, %: dry matter	9,39±0,04	1,44	9,22	9,58	8,97±0,08	3,78	8,63	9,15
fat	0,12±0,03	14,3	0,03	0,37	0,14±0,05	17,6	0,01	0,71
protein	1,65±0,02	3,72	1,53	1,75	1,42±0,01	4,19	1,30	1,55
lactose	6,87±0,03	1,39	6,74	7,03	6,72±0,09	5,41	5,38	6,97
Dry non-fat milk residue, %	9,27±0,02	0,92	9,15	9,58	8,86±0,09	4,38	7,45	9,15
Fat/protein ratio	0,07±0,02	14,5	0,02	0,15	0,08±0,03	16,6	0,01	0,49
Freezing point, °C	0,66±0,01	1,06	0,649	0,669	0,64±0,01	4,30	0,542	0,663
Somatic cell count, thousand/cm ³	0,39±0,27	24,8	2	3	2,35±1,50	26,3	3	255

The milk quality indicators of the studied mares in samples from the first and second milking per day are given in Table 2.

Table 2

Milk quality indicators of the studied mares for the 1st and 2nd milking

Milk quality indicators	June		August		Reference values
	1 milking	2 milking	1 milking	2 milking	
Content, %: dry matter	9,447±0,087	9,308±0,023	8,928±0,089	8,918±0,078	
fat	0,208±0,079	0,076±0,010	0,105±0,030	0,165±0,060	1,6-1,9
protein	1,613±0,014	1,649±0,020	1,408±0,016	1,345±0,014	2,1-2,2
lactose	6,877±0,029	6,833±0,025	6,701±0,091	6,697±0,085	5,8-6,4
Ratio: fat/protein	0,128±0,049	0,045±0,006	0,074±0,021	0,121±0,044	
Dry non-fat milk residue, %	9,241±0,028	9,233±0,021	8,824±0,098	8,752±0,090	7,0-10,0
Freezing point, °C	0,659±0,002	0,655±0,002	0,642±0,007	0,642±0,006	
Number of somatic cells, thousand/cm ³	0,308±0,208	0,438±0,302	1,706±0,903	3,353±2,356	

Note: * $p < 0.05$; ** $p > 0.1$

It was found that the indicators of daily milk yield and milk quality of experimental mares in samples taken in June and August are significantly correlated with each other (Table 4). The highest probable relationships are between the dry matter content in daily milk yield, the protein and dry matter content in samples obtained from the first milking, the amount of milk, the dry matter, fat and protein content in samples from the second milking.



Table 3

The relationship between indicators of milk productivity and milk quality of mares in milk samples obtained in June and August (r)

Milk quality indicators	Correlation coefficient ®		
	1 milking	2 milking	Daily milking
Amount of milk, l	0,769**	0,502*	0,687**
Content, %: dry matter	0,321*	0,528*	0,412*
fat	0,569**	0,708*	0,690**
protein	0,788*	0,342*	0,578*
lactose	0,303**	0,265**	0,281**
Dry non-fat milk residue, %	0,089*	0,067*	0,066*
Fat/protein ratio	0,557**	0,722**	0,704**
Freezing point, °C	0,299***	0,265***	0,280***
Somatic cell count, thousand/cm ³	-0,096**	-0,126**	-0,121**

Most milk quality indicators are significantly correlated with each other, as proven by the calculations of correlation coefficients (Table 4). The most positively correlated indicators in milk samples taken in June are dry matter and fat content, dry matter and ratio (fat/protein), dry matter and dry non-fat milk residue, fat content and ratio (fat/protein), lactose content and freezing point index, lactose content and dry non-fat milk residue. The somatic cell content was negatively correlated with all studied milk quality indicators.

Table 4

Correlations between milk quality indicators of mares of the Novoaleksandrovsk heavy-duty breed

Indicators	Dry matter	Fat	Protein	Fat/protein ratio	Lactose	dry non-fat milk residue, %	Freezing point, °C	Somatic cell content
June								
Dry matter		0,796	0,171	0,808	0,435	0,695	0,588	-0,493
Fat	-0,008		0,258	0,998	-0,067	0,120	0,098	-0,220
Protein	-0,311	0,355		0,221	-0,628	0,003	-0,532	-0,110
Fat/protein ratio	0,032	0,998	0,326		-0,028	0,141	0,136	-0,228
Lactose	0,860	-0,502	-0,548	-0,465		0,776	0,984	-0,329
dry non-fat milk residue, %	0,877	-0,486	-0,435	-0,450	0,992		0,833	-0,537
Freezing point, °C	0,893	-0,444	-0,526	-0,405	0,998	0,992		-0,393
Somatic cell content	-0,830	0,459	0,541	0,422	-0,996	-0,945	-0,954	
August								



In milk samples taken in August, the most positively correlated were the dry matter and lactose content, dry matter and dry non-fat milk residue, dry matter and freezing point index, fat content and ratio (fat/protein). The lactose content index was also highly and positively correlated with the dry non-fat milk residue content and freezing point index, negatively - with the fat, protein content and their ratio.

According to the technology adopted at the Dibrivsky stud farm, mating of mares, and accordingly their foaling, are seasonal, and therefore, the birth of experimental mares occurred in February-March. In this regard, the lactation period index in June fluctuated within the limits: 62-141 days; in August - 114-193 days. Accordingly, mares, based on the results of control milking in June, were distributed according to gradations: 62-90 (3 months), 91-120 (4 months), 121-141 days (5 months); in August: 114-150 (5 months), 151-180 (6 months), 181-193 (7 months).

Considering that the duration of lactation of the share of mares, whose control milking was carried out in June and August, fell on the 5th month, the gradations were adjusted in the summary according to the terms of lactation. In accordance with the established gradations, the value of daily milk yields was determined (Table 5).

Table 5

Indicators of daily milk yields of mares of the Novooleksandrivka heavy-duty breed depending on the terms of lactation

Lactation period, days	n	milk yield,kg		
		1 milking	2 milking	Daily milking
June (06/19/2024)				
62-90	2	1,55±0,35	2,65±1,70	4,20±1,70
91-120	6	0,90±0,10	1,63±0,21	2,47±0,24
121-141	8	1,13±0,07	1,48±0,10	2,66±0,17
On average:	16	1,097±0,079	1,684±0,180	2,781±0,240
August (08/10/2024)				
114-150	2	2,15±0,55	1,80±0,35	3,95±0,86
151-180	10	0,82±0,05	1,30±0,13	2,15±0,16
181-193	4	1,11±0,13	1,36±0,14	2,50±0,26
On average:	16	1,078±0,127	1,378±0,098	2,463±0,205

The highest daily milk yield was characterized by mares that began to lactate later. Thus, according to the indicators of control milking in June, the highest milk yield was distinguished by mares that were at the lactation stage of 62-90 days (4.20±1.70 kg, $p \leq 0.01$), and in August - at the lactation stage of 114-150 days (3.27±0.86, $p \leq 0.01$). The level of the correlation coefficient between daily milk yields and lactation periods was low, negative: lower in June ($r = -0.218$) and higher in August ($r = -0.374$).

Correlation analysis proved that the own daily milk yield of the same mares in June and August was significantly interconnected ($r = 0.695$). At the same time, the milk yield from the first milking correlated with a much greater strength ($r = 0.771$) than from the second ($r = 0.398$).

The results of studies on milk quality in connection with the term of lactation are given in Table 6.



Table 6

Milk quality indicators of experimental mares of the Novoaleksandrivka heavy-duty breed depending on the term of lactation

Milk quality indicators	Lactation dates			
	June			
n	62-90	91-120	121-141	r
	2	6	8	
Content, %: dry matter	9,435±0,195	9,377±0,051	9,338±0,038	-0,006*
fat	0,230±0,140	0,107±0,034	0,066±0,014	-0,331*
protein	1,675±0,015	1,682±0,023	1,623±0,023	-0,352*
lactose	6,790±0,030	6,838±0,051	6,894±0,023	0,497*
Ratio: fat/protein	0,135±0,085	0,062±0,020	0,041±0,008	-0,297*
Dry non-fat milk residue, %	9,205±0,055	9,273±0,036	9,270±0,027	0,369*
Freezing point, °C	0,653±0,004	0,656±0,004	0,659±0,002	0,457*
Number of somatic cells, thousand/cm ³	3	0	2	-0,384*
August				
n	114-150	151-180	181-193	r
	2	10	4	
Content, %: dry matter	9,305±0,305	8,891±0,123	8,995±0,013	-0,206*
fat	0,375±0,335	0,084±0,041	0,048±0,016	-0,251*
protein	1,430±0,010	1,440±0,017	1,390±0,041	-0,153*
lactose	6,775±0,035	6,663±0,149	6,830±0,031	-0,035*
Ratio: fat/protein	0,260±0,230	0,056±0,026	0,035±0,012	-0,259*
Dry non-fat milk residue, %	8,930±0,030	8,813±0,161	8,948±0,020	-0,066*
Freezing point, °C	0,651±0,001	0,639±0,011	0,651±0,002	-0,059*
Number of somatic cells, thousand/cm ³	0	26,7±25,4	3	0,101*

Note: * $p < 0.05$

It was found that the highest dry matter content was in milk samples taken in June from mares at the earliest stages of lactation (62-90 days). Accordingly, the fat content in milk was higher in samples taken from mares at the early stages of lactation, and the lactose content, on the contrary, increased in samples from mares at the later stages of lactation. The content of protein, dry non-fat milk residue and freezing point index did not change almost at all.

In August, the highest dry matter and fat content, as well as the fat/protein ratio in milk samples from mares were also at the earliest stages of lactation (114-150 days). The protein content in milk was significantly higher in mares at 151-180 days of lactation, and the lactose and SZZM content was at 191-193 days of lactation. The freezing point index was the same in the milk of mares at the earliest and latest stages of lactation (0.651) and slightly lower at 151-180 days of lactation.

The determination of correlations established a high positive effect of the duration of lactation on the content of lactose in milk ($r=0.497$), dry non-fat milk residue ($r=0.369$)



and freezing point ($r=0.457$) in samples taken in June, the remaining relationships are negative. In milk samples taken in August, the duration of lactation is most (negatively) correlated with the fat/protein ratio, fat and dry matter content in milk.

The influence of mares' age on daily milk yield is given in Table 7, the data of which prove the superiority of daily milk yield of mares aged 9-13 years in June, and older ones (14 years and older) in August. The level of the correlation coefficient between daily milk yield and mares' age was positive, of medium strength, almost the same in June ($r=0.431$) and August ($r=0.352$).

Table 7

Daily milk yield of mares of the Novooleksandrivka heavy-duty breed depending on the age of the mares

Age of mares, days	n	Milk yield,kg		
		1 milking	2 milking	Daily milking
June				
4-8 years	6	0,883±0,087	1,400±0,100	2,283±0,180
9-13 years	6	1,192±0,156	2,033±0,445	3,225±0,564
14 years and older	4	1,275±0,075	1,588±0,156	2,863±0,221
Average:	16	1,097±0,079	1,684±0,180	2,781±0,240
August				
4-8 years	6	0,842±0,052	1,425±0,070	2,267±0,087
9-13 years	6	1,167±0,313	1,217±0,240	2,400±0,531
14 years and older	4	1,300±0,147	1,550±0,106	2,850±0,205
Average:	16	1,078±0,127	1,378±0,098	2,463±0,205

The influence of mares' age on milk quality indicators is given in Table 8, the data of which prove the superiority of dry matter content in milk of mares aged 10-13 years in June, and older (14 years and older) in August. In groups of mares of the same age category, the fat content in milk was higher. The protein content was highest in milk of mares aged 4-8 years in both June and August, and the lactose content in the oldest mares. The freezing point indicator differed little in different groups of mares, but was higher in older mares (14 years and older). The correlation indicators between the age of mares and the quality indicators of their milk in June and August were low.

The age of mares affects the duration of their foaling, as evidenced by a positive probable correlation coefficient of medium degree ($r=0.396$).



Table 8

Milk quality indicators of experimental mares of the Novoaleksandrovsk heavy-duty breed depending on the age of the mares

Milk quality indicators	Age of mares, years			
	June			
n	4-8	9-13	14 and older	r
	6	6	4	
Content, %: dry matter	9,360±0,060	9,425±0,063	9,348±0,073	0,139**
fat	0,063±0,07	0,168±0,022	0,075±0,022	0,153*
protein	1,677±0,038	1,648±0,022	1,638±0,040	-0,005*
lactose	6,870±0,083	6,857±0,033	6,885±0,052	0,046*
Ratio: fat/protein	0,037±0,003	0,100±0,030	0,045±0,013	0,161*
Dry non-fat milk residue, %	9,303±0,058	9,253±0,024	9,275±0,061	0,049**
Freezing point, °C	0,657±0,006	0,657±0,002	0,659±0,004	0,089*
Number of somatic cells, thousand/cm ³	0	2	3	0,244*
August				
n	4-8	9-13	14 and older	r
	6	6	4	
Content, %: dry matter	8,970±0,082	8,947±0,233	9,000±0,012	0,075***
fat	0,043±0,016	0,227±0,116	0,040±0,011	0,185*
protein	1,442±0,017	1,410±0,035	1,428±0,021	-0,057*
lactose	6,770±0,070	6,608±0,248	6,808±0,012	-0,017*
Ratio: fat/protein	0,030±0,010	0,155±0,078	0,028±0,009	0,186
Dry non-fat milk residue, %	8,938±0,088	8,718±0,257	8,960±0,008	-0,033***
Freezing point, °C	0,647±0,006	0,636±0,019	0,650±0,001	-0,007*
Number of somatic cells, thousand/cm ³	2,000±1,291	43,000±42,403	0	0,041***

Note: * $p < 0.05$; ** $0.1 > p > 0.05$; *** $p > 0.1$

The duration of foaling of experimental mares was on average 335.6 ± 2.85 days (lim=320–358) ($Cv=3.176$). The influence of the duration of pregnancy of mares on the indicators of daily milk yield is given in Table 9. The advantage in daily milk yield of mares with a duration of foaling over 350 days was proven according to the results of control milking in both June and August.

Daily milk yield significantly and positively correlated with high probability ($p < 0.01$) with the duration of pregnancy of experimental mares in June ($r=0.759$), for milk yields in August this correlation was significantly lower ($r=0.270$). The duration of pregnancy was positively and significantly correlated with the age of mares in the average degree ($r=0.429$). It was established that foals were carried by mares for 9.1 days longer than fillies ($p < 0.05$).



Table 9

Indicators of daily milk yield of mares of the Novooleksandrivka heavy draft breed depending on the duration of pregnancy

Pregnancy duration, days	n	Milk yield,kg		
		1 milking	2 milking	Daily milking
June (06/19/2024)				
320-330	4	0,867±0,186	1,233±0,088	2,100±0,265
331-340	7	1,000±0,049	1,429±0,071	2,500±0,076
341 and more	5	1,213±0,142	1,988±0,218	3,200±0,117
On average:	16	1,097±0,079	1,684±0,180	2,781±0,240
August (08/10/2024)				
320-330	4	1,015±0,009	1,283±0,017	2,317±0,044
331-340	7	0,857±0,047	1,400±0,072	2,257±0,083
341-350	5	0,988±0,200	1,200±0,331	2,188±0,503
On average:	16	1,078±0,127	1,378±0,098	2,463±0,205

The influence of the duration of pregnancy of mares on milk quality indicators is given in Table 10.

Table 10

Milk quality indicators of experimental mares of the Novooleksandrivka heavy-duty breed depending on the duration of their pregnancy

Milk quality indicators	Duration of pregnancy, years			
	June			
n	320-330	331-340	341 and more	r
	4	7	5	
Content, %: dry matter	9,267±0,015	9,338±0,060	9,628±0,204	0,369*
fat	0,067±0,003	0,100±0,033	0,298±0,187	0,242*
protein	1,583±0,032	1,625±0,025	1,620±0,032	0,206*
lactose	6,873±0,039	6,865±0,069	6,950±0,039	0,300*
Ratio: fat/protein	0,043±0,003	0,063±0,021	0,183±0,117	0,230*
Dry non-fat milk residue, %	9,203±0,017	9,240±0,060	9,330±0,028	0,497*
Freezing point, °C	0,657±0,003	0,657±0,005	0,666±0,004	0,364*
Number of somatic cells, thousand/cm ³	0	2	2	0,024*
August				
n	320-330	331-340	341 and more	r
	4	7	5	
Content, %: dry matter	8,930±0,056	9,001±0,064	8,773±0,298	-0,080*
fat	0,037±0,022	0,046±0,013	0,148±0,098	0,220*
protein	1,393±0,035	1,426±0,024	1,450±0,038	0,203*
lactose	6,787±0,024	6,803±0,062	6,493±0,373	-0,147*
Ratio: fat/protein	0,027±0,017	0,033±0,008	0,098±0,061	0,221*
Dry non-fat milk residue, %	8,903±0,041	8,959±0,073	8,625±0,395	-0,127*
Freezing point, °C	0,648±0,002	0,650±0,005	0,626±0,028	-0,139*
Number of somatic cells, thousand/cm ³	0	2,143±1,100	225	0,144*

Note: * $p < 0.05$; ** $0.1 > p > 0.05$; *** $p > 0.1$



The superiority in dry matter, fat and fat-protein ratio in milk samples of experimental mares with a gestation period of more than 340 days was proven according to the results of control milking in both June and August. This gradation of mares also had the highest lactose content and freezing point index in samples taken in June and protein in samples taken in August. In mares whose gestation period was 331-340 days, the highest protein content and dry non-fat milk residue in milk samples obtained in June and freezing point index in samples obtained in August were found.

It was found that mares that foaled with foals had a high degree of probability ($p < 0.01$) higher daily milk yield, as well as milk yields for the first and second milking (Table 11). This may be due to the fact that foals are born larger and require a larger amount of milk, which is controlled by the hormonal background of the mare (Aoki T., 2013; Robles M., 2018). Milk yield in June in mares that gave birth to foals was significantly higher (by 0.511 l, $p < 0.01$) than in August. In mares that gave birth to fillies, the milk yield level remained unchanged with minor fluctuations in the indicator between the first and second milking.

Table 11

Daily milk yield indicators of mares of the Novoaleksandrovsk heavy-duty breed depending on the month of milking and the sex of the foals

The sex of the foal	n	Milk yield, kg		
		1 milking	2 milking	Daily milking
June (19.06.2024)				
Stallions	10	1,094±0,078	1,628±0,148	2,722±0,168
fillies	6	0,910±0,046	1,410±0,105	2,320±0,085
August (10.08.2024)				
Stallions	10	0,933±0,091	1,267±0,137	2,211±0,210
fillies	6	0,920±0,107	1,400±0,114	2,320±0,208

The milk quality indicators of the studied mares depending on the sex of their foals are given in Table 12.

Table 12

Quality indicators of the daily milk yield of mares depending on the sex of their foals

Milk quality indicators	June		August	
	stallions	filly	stallions	filly
Content, %: dry matter	9,440±0,043	9,265±0,021	8,992±0,136	8,930±0,071
fat	0,140±0,036	0,060±0,013	0,156±0,073	0,036±0,012
protein	1,644±0,021	1,668±0,031	1,435±0,018	1,412±0,028
lactose	6,900±0,032	6,798±0,025	6,688±0,147	6,770±0,070
Dry non-fat milk residue, %	9,300±0,028	9,208±0,023	8,834±0,156	8,907±0,081
Fat/protein ratio	0,083±0,021	0,035±0,006	0,106±0,049	0,027±0,008
Freezing point, °C	0,660±0,002	0,652±0,002	0,642±0,011	0,647±0,005
Somatic cell count, thousand/cm ³	0	1,250±0,750	26,00±25,45	1,667±1,174



It was found that in milk samples (selected both in June and August) from mares that gave birth to foals, the content of dry matter was higher (by 0.448 and 0.335 ml, respectively), fat (by 0.08 and 0.12%, respectively), and the ratio of fat to protein. The protein content was higher in samples taken in June from mares that gave birth to fillies, and in August from those that gave birth to foals, however, the difference is small and insignificant. The lactose content, on the contrary, was higher in samples taken in June from mares that gave birth to foals, and in August from mares, the same trend was observed in terms of dry non-fat milk residue and freezing point. A small number of somatic cells was detected in samples taken in June from two mares that gave birth to fillies, in August from four mares that gave birth to foals of both sexes.

Discussion. The results of our studies have proven the influence of the month of lactation on the quantity and quality of milk of mares of the Novoaleksandrivka heavy draft breed, with more milk being obtained from the second milking. All milk samples showed low fat and protein content and high lactose content, which is also confirmed by other researchers (Malacarne et al., 2002; Ciesla et al., 2009; Goncharenko, 2012). The dry matter, protein, lactose and SMP content were higher in June, and the protein content (and, accordingly, the fat-protein ratio), freezing point and the number of somatic cells (detected only in a few mares in insignificant quantities) were higher in August. In milk examined in both June and August, a higher content of almost all milk quality indicators was found in samples from the first milking.

High probable positive correlations were established between daily milk yield and dry matter content, fat, and fat-protein ratio. In milk milked in August, these relationships were weaker. In all samples, a negative relationship was established between the amount of milk and the content of somatic cells.

The effect of lactation duration on daily milk yield and milk quality indicators of experimental mares was proven. Thus, the highest daily milk yield was recorded in mares that began lactating later and were in June at 62-90 days, and in August at 114-150 days of lactation. Morresey, (2012) also emphasizes that mares produce the highest amount of milk in the first months of lactation. The highest dry matter, fat and fat/protein ratio were found in milk samples collected in June from mares at the earliest stages of lactation (62-90 days). The protein, dry non-fat milk residue and freezing point values remained almost unchanged. The number of somatic cells was insignificant, and they were not detected at all in milk samples from most mares. In August, the highest dry matter and fat content, as well as the fat/protein ratio, were found in milk samples from mares also at the earliest stages of lactation (114-150 days). The protein content in milk was significantly higher in mares at 151-180 days of lactation, and the lactose content ($r=0.497$) and SZZM ($r=0.369$) at 191-193 days of lactation. The freezing point index was the same in the milk of mares at the earliest and latest stages of lactation (0.651) and slightly lower at 151-180 days of lactation ($r=0.457$).

The influence of the age of mares on the daily milk yield indicators was proven, which is confirmed by the superiority in daily milk yield of mares aged 9-13 years in June ($r=0.431$), and older (14 years and older) ($r=0.352$) in August. In terms of dry matter content in milk, mares aged 10-13 years prevailed in June, and older (14 years and older) in August. In groups of mares of the same age category, the fat content in milk was higher, the protein content was highest in the milk of mares aged 4-8 years in both June and August, and the lactose content was highest in the oldest mares. The freezing point index differed little in different groups of mares, but was higher in older mares (14 years and older).

It was found that the duration of foaling in experimental mares was on average 335.6 ± 2.85 days ($lim=320-358$) ($Cv=3.176$) and was associated with the age of the



experimental mares ($r=0.396$) and the sex of the fetus - mares carried foals for 9.1 days longer than fillies ($p<0.05$). Aoki T. (2013) provides similar data from the study of heavy-duty mares, the duration of pregnancy of which was on average 334.9 ± 8.3 days, and also proves that the sex of the foal is one of the main factors affecting the duration of pregnancy in heavy-duty mares.

The influence of mares' age on daily milk yield indicators was proven, which is confirmed by the superiority of mares aged 9-13 years in June ($r=0.431$), and older mares (14 years and older) ($r=0.352$) in August. In terms of dry matter content in milk, mares aged 10-13 years in June, and older mares (14 years and older) prevailed. In groups of mares of the same age category, the fat content in milk was higher, the protein content was highest in the milk of mares aged 4-8 years in both June and August, and the lactose content was highest in the oldest mares. The freezing point indicator differed little in different groups of mares, but was higher in older mares (14 years and older).

It was found that the duration of foaling in experimental mares was on average 335.6 ± 2.85 days (lim=320–358) ($Cv=3.176$) and was related to the age of experimental mares ($r=0.396$) and the sex of the fetus - mares carried foals for 9.1 days longer than mares ($p<0.05$). Aoki T. (2013) provides similar data from the study of heavy-duty mares, the duration of pregnancy of which was on average 334.9 ± 8.3 days, and also proves that the sex of the foal is one of the main factors affecting the duration of pregnancy in heavy-duty mares. The advantage in daily milk yield of mares with a duration of foaling over 350 days was proven according to the results of control milking in both June and August. Similar results were reached by Auclair-Ronzaud et al. (2022), who proved that older mares had higher milk yield than young ones. In terms of dry matter, fat, and fat-to-protein ratio in milk samples, experimental mares with a gestation period of over 340 days prevailed according to the results of control milking in both June and August. This gradation of mares also had the highest lactose content and freezing point index in samples taken in June and protein in samples taken in August. In mares whose gestation period was 331-340 days, the highest protein and dry non-fat milk residue content in milk samples obtained in June and the freezing point index in samples obtained in August were found. It was found that mares that foaled with foals had a high degree of probability ($p<0.01$) higher daily milk yield. Aoki T. (2013) and Robles M. (2018) attribute this fact to the fact that foals require a larger amount of milk, which is controlled by the hormonal background of the mare. Milk yield in June in mares that gave birth to foals was significantly higher (by 0.511 l, $p<0.01$) than in August. In mares that gave birth to fillies, the milk yield level remained unchanged with minor fluctuations in the indicator between the first and second milking. At the same time, the milk of mares that gave birth to foals, both in June and August, had a higher content of dry matter (by 0.448 and 0.335 ml, respectively), fat (by 0.08 and 0.12 %, respectively), and the ratio of fat to protein. The lactose content, on the contrary, was higher in samples taken in June from mares that gave birth to foals, and in August - mares, the same trend in terms of dry non-fat milk residue and freezing point. A small number of somatic cells was detected in samples taken in June from two mares that gave birth to fillies, in August - from four mares that gave birth to foals of both sexes.

Conclusions:

1. It was established that the factors of month, milking number, lactation period, age of mares of the Novoaleksandrivka heavy draft breed, duration of their pregnancy and sex of foals to varying degrees affect the daily milk yield and indicators of its quality.
2. Daily milk yield was higher in June than in August, while in both June and August more milk was obtained from the second milking (by 0.587 l in June and 0.300 l in August). In the milk samples of mares taken in June, a higher content of dry matter,



protein, lactose and SPPW was observed, and the protein content, fat-to-protein ratio, freezing point and the number of somatic cells were higher in the samples taken in August. Almost no somatic cells were detected in the milk of the studied mares, which is explained by its high antibacterial properties. In the milk of the experimental mares taken in both June and August, a higher content of almost all the studied indicators in the milk samples from the first milking was found.

3. A high level of correlation was established between the daily milk yield of milk collected in June and the content of dry matter ($r=0.856$), fat ($r=0.728$), and the ratio of fat to protein ($r=0.861$). In milk collected in August, these correlations were weaker (0.634, 0.461, and 0.489, respectively). In all samples, a negative correlation was established between the amount of milk and the content of somatic cells.

4. It was determined that foaling (birth) of mares is seasonal, and therefore, births of experimental mares occurred in February-March, the lactation period indicator in June fluctuated within the limits: 62-141 days; in August - 114-193 days. The highest daily milk yield was characterized by mares that began to lactate later. By determining the correlation relationships, a high positive effect of the duration of lactation on the content of lactose in milk ($r = 0.497$), dry non-fat milk residue ($r = 0.369$) and freezing point ($r = 0.457$) in samples taken in June was established, the remaining relationships are negative. In milk samples collected in August, the duration of lactation is most (negatively) correlated with the fat/protein ratio, fat and dry matter content in milk.

5. The superiority of mares aged 9-13 years in terms of daily milk yield and dry matter and fat content in milk samples collected in June, and of older mares (14 years and older) in terms of daily milk yield and freezing point in milk samples collected in August, has been proven. The level of the correlation coefficient between daily milk yields and the age of mares was positive, of medium strength, almost the same in June ($r=0.431$) and August ($r=0.352$).

6. It was established that the duration of foaling (pregnancy) of experimental mares on average was 335.6 ± 2.85 days (lim=320–358). Daily milk yield was significantly and positively correlated with high probability ($p<0.01$) with the duration of pregnancy of experimental mares in June ($r=0.759$), for milk yields in August this correlation was significantly lower ($r=0.270$). The duration of pregnancy was positively and significantly correlated with the age of mares in the average degree ($r=0.429$), while mares carried foals for 9.1 days longer than mares ($p<0.05$). The superiority in dry matter content, fat, fat-to-protein ratio, lactose and freezing point index in milk samples of experimental mares with a duration of foaling over 340 days was proven according to the results of control milking in both June and August. In mares whose gestation period was 331-340 days, the highest protein and dry non-fat milk residue content in milk samples obtained in June and the freezing point index in samples obtained in August were found.

7. It was found that mares that foaled with foals had a high degree of probability ($p<0.01$) higher daily milk yield, as well as milk yields for the first and second milking, their daily milk yield in June was significantly higher (by 0.511 l, $p<0.01$) than in August. In mares that gave birth to fillies, the level of milk yield remained unchanged with minor fluctuations in the indicator between the first and second milking. In milk samples (taken both in June and August) from mares that gave birth to foals, the dry matter content, fat (by 0.08 and 0.12%, respectively), and the fat-to-protein ratio were higher. The protein content in all sections differed slightly and insignificantly. The lactose content, on the contrary, was higher in samples taken in June from mares that gave birth to foals, and in August from mares, the same trend was observed in terms of dry non-fat milk residue and freezing point. A small number of somatic cells was detected in samples taken in June



from two mares that gave birth to fillies, and in August from four mares that gave birth to foals of both sexes.

References

- Aoki T., Yamakawa K., Ishii M. (2013). Factors Affecting Gestation Length in Heavy Draft Mares. *Journal of Equine Veterinary Science*, Vol. 33, Iss. 6: 437-440, <https://doi.org/10.1016/j.jevs.2012.07.011>
- Auclair-Ronzaud, J., Jaffrézic, F., Wimel, L., Dubois, C., Laloë, D., & Chavatte-Palmer, P. (2022). Estimation of milk production in suckling mares and factors influencing their milk yield. *Animal*, 16(4), 100498
- Blanco-Doval, A; Luis, Javier R. Barron; Noelia, A. (2024). Nutritional Quality and Socio-Ecological Benefits of Mare Milk Produced under Grazing Management. *Foods*, 13(9), 1412. doi:10.3390/foods13091412
- Ciesla, A., Palacz R., Janiszewska J., and Skorka D. (2009). Total protein, selected protein fractions and chemical elements in the colostrum and milk of mares (Short Communication). *Arch. Anim. Breed.* 52:1-6. doi:10.5194/aab-52-1-2009
- Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific. (2010). Retrieved from <https://www.fao.org/faolex/results/details/ru/c/LEXFAOC098296/>
- Doreau, M.; Martin-Rosset, W. (2011). Animals that produce dairy foods: Horse. *Encyclopedia of Dairy Sciences*; Fuquay, J.W., Fox, P.F., McSweeney, P.L.H., Eds.; Academic Press: San Diego, CA, USA, 358–36
- Gall, C. F. (2013). Production systems around the world. *Milk and Dairy Products in Human Nutrition: Production, Composition and Health*, 1-30. <https://doi.org/10.1002/9781118534168.ch1>
- Honcharenko I. B. (2012). Vyrobnystvo kumysu – perspektyvnyy napryam rozvytku produktyvnoho konyarstva. [Production of kumis is a promising direction for the development of productive horse breeding]. *Scientific bulletin of the Lviv NUVMtaB named after S.Z. Gzhitskyi: "Agricultural Sciences" series*. Lviv, vol. 14. 3(53), 3: 278-284.
- European convention for the protection of vertebrate animals used for experimental and other scientific purposes. (1986). Retrieved from <https://rm.coe.int/168007a67b>
- Iskhan, K. Zh, Akimbekov, A. R., Baimukanov, A. D., Aubakirov, Kh. A., Karynbayev, A. K., Rzabayev, T. S., Mukhatai Geminguli, Dzhunusova, R. Z., Apeev, K. B. (2019). Dairy productivity of the kazakh horse mares and their cross breeds with roadsters. *Bulletin of national academy of sciences of the republic of Kazakhstan*. Vol. 3, N 379:22-35. doi.org/10.32014/2019.2518-1467.65
- Kunying Lv, Yixin Yang, Qilong Li, Ran Chen, Liang Deng, Yiwei Zhang, Ning Jiang. (2024). Identification and comparison of milk fat globule membrane and whey proteins from Selle Français, Welsh pony, and Tieling Draft horse mare's milk. *Food Chemistry*. Vol. 437, 2:137915. doi:10.1016/j.foodchem.2023.137915
- Malacarne, M., Martuzzi F., Summer A., Mariani P. (2002). Protein and fat composition of mare's milk: some nutritional remarks with reference to human and cow's milk. *Int. Dairy J.* 12:869-877. doi:10.1016/s0958-6946(02)00120-6
- Morresey, P.R. (2012). Agalactia, dysgalactia, and nutrition of the postpartum mare. In: AAEP Annual Convention, Anaheim, CA, USA; p. 370-374
- Musaev, A., Sadykova, S., Anambayeva, A., Saizhanova, M., Balkanay, G., Kolbaev, M. (2021). Mare's Milk: Composition, Properties, and Application in Medicine. *Archives of Razi Institute*, Vol. 76, No. 3 (2021) 1125-1135. doi: 10.22092/ari.2021.355834.1725



- Naymanov D. K., Turbaev A. T., Bakhtybayev G. T., Seleuova L. A. (2018). Herd horse breeding: study guide. Kustanai: KSU named after A. Baitursynov, 238 p
- Pieszka, M.; Łuszczynski, J.; Zamachowska, M.; Augustyn, R.; Długosz, B.; Hędrzak, M. (2016). Is mare milk an appropriate food for people? – a review. *Annals of Animal Science*, 16, 33-51
- Robles M., Peugnet P.M., Valentino S.A., Dubois C., Dahirel M., Aubrière M.-C., Reigner F., Serteyn D., Wimmel L., Tarrade A., Chavatte-Palmer P. (2018). Placental structure and function in different breeds in horses. *Theriogenology*, Vol. 108: 136-145. <https://doi.org/10.1016/j.theriogenology.2017.11.007>
- Seleuova L. A., Brel-Kiseleva I. M., Sofronova O. C. (2017). Current state and prospects for the development of breeding horse breeding in the Republic of Kazakhstan. Mat. international scientific and practical conf. Science without borders. Sheffield, GB: 99-104
- Turabayev, A. T. (2015). The role of the Kazakh horse in the formation of horse breeds of the Republic of Kazakhstan. Ualikhanovskie readings-19: collection of mat. mat. international. scientific and practical conf. Kokshetau: 242