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Technological environment and feeding of dairy cows under conditions of keeping in a cros-barn

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Abstract. Dairy farming is one of the most important branches of animal husbandry, as it provides essential food products to the population and raw materials to milk processing enterprises. The study was aimed at investigating how the conditions of keeping and feeding with complete monomixes affect the level of milk productivity of Holstein first-calf heifers during first lactation period. The animals in the experimental group were kept in a microclimate controlled cros-barn, while those in the control group were kept in a pavilion-type barn with natural ventilation. The intensity of lactation in the first half was analysed and it was found that in cows of the experimental group, the yield per 100 days and on the peak day of lactation was, respectively, 103.3 kg ($p < 0.001$) and 1.1 kg ($p < 0.05$) higher than in animals of the control group. The analysis showed that cows in the experimental group with high productivity (>9643 kg) had a longer period of reaching peak lactation. This indicator exceeded the duration of the same period in cows from the groups with productivity "<8423" and "8424-9642" by 20.3 ($p < 0.001$) and 5.9 ($p < 0.001$) days, respectively. In addition, within the experimental group, cows with shortened, average, and prolonged reproductive cycles had higher milk yields during the first 100 days of lactation – by 94.0 kg ($p < 0.001$), 115.6 kg ($p < 0.001$), and 93.4 kg ($p < 0.001$), respectively, compared to their peers in the control group with a similar distribution of cycle duration. A summary of the results for the combined indicators showed that the animals in the experimental group demonstrated better production and physiological characteristics compared to the control group. Thus, keeping Holstein cows in a cros-barn provides a comfortable technological environment that meets biological needs in the first half of lactation, minimises heat stress, and promotes the realisation of genetic potential for high productivity. The material is relevant for livestock breeders and technologists in milk production in industrial complexes

Keywords: holstein breed; cows maintenance; lactation; milk productivity; reproductive capacity

INTRODUCTION

Increasing gross milk production remains a challenging and strategically important issue in modern dairy farming. This task is being addressed not only through genetic improvement of cattle and selection of high-yielding specimen, but also through comprehensive improvement of husbandry, feeding, and care technologies. Spatial planning solutions in livestock buildings are also important, as they ensure an optimal

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microclimate, adequate hygiene, comfort, and reduced stress factors for animals. Creating a favorable technological environment makes it possible to more fully realise the genetic potential of specialised dairy breeds, since it is under conditions that are as close as possible to their biological needs that the productive capabilities of the organism are effectively realised. A rational combination of genetic, technological, and organisational factors is a key prerequisite for increasing herd productivity, improving reproductive performance, and ensuring the stable development of dairy farming as a whole.

Particular productivity growth has been achieved in agricultural enterprises that have significantly greater technological capabilities to ensure conditions for effective dairy farming and high-quality milk production. The main directions for the development of highly intensive dairy farming are a solid feed base, stable state support, a well-established veterinary service system, and the need to improve the management mechanism of a progressive system of milk production intensification based on the use of a highly productive loose housing system for cows (Antoshchenkova, 2020). Research conducted by M.M. Lutsenko & I.O. Lastovs'ka (2022) showed the significant advantages and prospects of loose housing of high-yielding cows in easily assembled barns with a width of 32.5 and 36 m. It has been established that new spatial planning and technological solutions for housing highly productive cows provide comfortable conditions. The presence of side curtains and light ventilation ridges in the design of the premises increases the air velocity more than threefold (0.5 m/s vs. 0.16 m/s), the ammonia content in the air of the premises is reduced by 8-9 times compared to traditional cowsheds, and bacterial contamination is reduced to a minimum (2.8 thousand/m^3 at $P > 0.999$) due to an increase in the volume of the premises to 129.6 m^3 per head.

M.R.H. Rakib *et al.* (2020) proved that the financial efficiency of dairy farming is determined by many factors that combine the effective use of production, material, and labor resources. At the same time, it was emphasised that in order to obtain a large amount of high-quality products, first of all, it is necessary to create optimal conditions for keeping cows, ensuring comfortable climatic and microclimatic conditions depending on the physiological state of the animals. L.M. Sorathiya (2024) noted that the introduction of integrated dairy farming practices that prioritise livestock welfare not only improves health and reduces stress, but also leads to increased productivity and sustainable development of dairy farming. Emphasising the interdependence of dairy cattle welfare and productivity, attention was drawn to feeding animals with high-quality feed, which is important for maintaining animal health and milk production.

One of important conditions for high productivity, reproductive qualities, and health preservation in animals is their proper nutrition. In particular, the content and ratio of minerals in their diet is crucial. Optimising the mineral and vitamin nutrition of cows through the use of mineral and vitamin supplements helps to normalise metabolism and increases productivity. The absence, deficiency, or excess of certain mineral elements, as well as an imbalance of their ratio in diets, leads to a decrease in the efficiency of feed nutrient utilisation, a decrease in animal productivity, and disease development (Valldecabres & Silva-del-Rno, 2022). A study by V.A. Hlavatchuk (2024) showed that adding a mineral and vitamin premix to the diet of dairy cows balanced its composition in terms of phosphorus, manganese, copper, zinc, iodine, cobalt, vitamin D, and selenium. This had a positive effect on milk productivity, the chemical composition of milk, and the reproductive functions of the animals. The average daily yield of natural fat milk increased by 1.5 kg or 5.9%, the mass fraction of fat and protein in milk by 0.05 and 0.07%; the duration of the service and inter-calving periods was reduced by 8 days, and the insemination index decreased by 10.3%. The increase in cow productivity was accompanied by a decrease in feed consumption per 1 kg of milk by 0.09 energy feed units.

According to A.T. Tsvigun *et al.* (2021), with a milk yield of 25-30 kg per day, dry matter intake should be 16-20 kg with an metabolisable energy of over 14 MJ. The simplest solution to this problem is to divide the herd into groups with more uniform productivity. Dividing the herd into production groups is, to a certain extent, a compromise and cannot completely solve the problem of standardised feeding. V.S. Kozyr (2022) emphasised the importance of balanced nutrition for dairy cattle, as it satisfies their daily need for interrelated nutrients (protein, fat, carbohydrates), minerals, trace elements, and vitamins in optimal proportions. With such a diet, which is based on the energy and protein value of feed, the animals' bodies develop, grow, and function normally.

Therefore, in order to avoid negative environmental influences, in particular high temperatures and humidity, it is necessary to control the number of animals in the sections; ensure intensive ventilation of the cowshed using fans to create air circulation and an optimal microclimate. Along with the maintenance conditions, maximum comfort of the technological environment for dairy cattle is ensured by feeding animals with fresh feed and providing free access to water, especially during the hot season. The aim of the study was to evaluate the intensity of lactation during the calving period of first-calf Holstein cows under comfortable conditions in a cross-barn and feeding with complete monomixes from feeder trays.

MATERIALS AND METHODS

The scientific and experimental research was conducted at a breeding farm for Holstein cattle, "Promin" Agricultural Limited Liability Company (ALLC) in Mykolaiv Oblast. This farm is one of the leaders in the dairy business, where intensive milk production technology is based on loose housing of cows, feeding them complete mono-mixtures from feeding tables, and milking them on an automated Carousel-type conveyor-ring milking machine with 80 cow slots. These technical and technological solutions contributed to high levels of productivity in animals. Milk yield per cow averaged 12703 kg in 2023 and 13200 kg in 2024 (Pidpala & Holosnyi, 2024).

Using Dairy Comp and Microsoft Excel, two groups were formed: experimental (n = 300) – animals were kept in a cross-barn with artificial ventilation, and control (n = 300) – animals were kept in a pavilion-type barn with natural ventilation. The comfort of the technological environment for Holstein cows, especially during the hot summer period, was ensured by keeping them loose in a cros-barn with an artificially controlled microclimate. Depending on the specific zone, the air in the room moved at a speed of 0.5-3.0 m/s in one direction – across the building. The barn, 356 m long and 4-6 m high, is equipped with 114 exhaust fans on one side along the entire perimeter, each with a diameter of over 1 m and a power of 2.5 kW. Due to the power of the exhaust ventilation system, the air in the building was expelled outside and intensive air exchange took place, ensuring the best gas composition of the air, i.e., the lowest gas content in the room. In addition, in the rest area, the air movement accelerated to 2.5 m/s and a noticeable breeze was created, which cooled the animals during their rest, i.e., cooling off the cows by the airflow. This ventilation minimised heat stress in cows during the summer and also ensured cleaner air due to its circulation. An optimal microclimate with the required temperature and air velocity was maintained using a special computer program. The rest area was equipped with beds with clean bedding, which consisted of solid manure.

Cows were fed a mixed diet (complete monomix) from the feeding trays with 80 cm long feeding front. To prepare and distribute feed mixtures, the author's feed and mobile feed dispensers/crushers (mixers) were used. The optimal grinding and homogeneity of the general mixed ration was achieved thanks to the developed technology of sequential loading of feed into the mixer hopper. First, straw and hay were loaded, then silage and haylage, and finally, compound feed and diluted molasses, which not only added flavor to the total mixed ration but also acted as a binder for the crushed feed and regulated the moisture content of the complete mono-mixture. To prevent acidosis and improve feed quality during the preparation of the total mixed ration, baking soda was used in an amount of 1% in the compound feed. For feeding cows in the first half of lactation, a ration was developed (Table 1), which contained, based on consumption per head: dry matter – 28.2 kg (experimental group) and 27.3 kg (control group), compound feed – 12.69 kg (experimental group) and 11.17 kg (control group). In terms of the composition of different types of feed, the general mixed diet was similar and met the biological needs of highly productive animals in the first half of lactation.

Table 1. *Nutrition ration for experimental cows in the first half of lactation (14-160 days)*

Feed	Physical mass, kg	Dry matter, kg	Feed	Physical mass, kg	Dry matter, kg
silage	27.5	9.71	soybean oilcake	1.900	1.672
corn silage	1	0.65	wheat	1.000	0.880
rye silage	8.7	2.86	limestone flour	0.160	0.141
straw	0.35	0.30	corn gluten	0.350	0.308
molasses	1.5	1.13	polfamix premix	0.150	0.132
sunflower	0.5	0.45	salt	0.130	0.114
alfalfa silage	3.50	1.13	sodium bicarbonate	0.160	0.141
water	1.5	0.00	rumen-protected fat	0.200	0.176
compound feed	12.69	11.17	buffer for cows	0.070	0.062
including:	-	-	feed-grade urea	0.050	0.044
corn	5.500	4,840	magnesium oxide	0.040	0.035
rapeseed oilcake	1.100	0.968	monocalcium phosphate	0.030	0.026
soybean oilcake	0.700	0.616	bentonite	0.050	0.044
sunflower oilcake	1.100	0.968	-	-	-
total mixed ration per cow, per day		cros-barn		57.5	28.2
		pavilion-type barn		56.1	27.3

Note: *the average moisture content of the total mixed ration during this period was 48.6%*
Source: *authors' data obtained in the laboratory of "Promin." ALLC*

Control over the adequate feeding of high-yielding cows was carried out by predicting dry matter intake based on actual initial data (Tsvigun *et al.*, 2021), and rations were balanced taking into account daily productivity, dry matter intake, energy balance, and changes in body condition during lactation. Optimal moisture content was monitored using an express method by drying samples of the total mixed ration in a microwave oven. Lactation intensity was assessed based on indicators in the first 100 days after calving in experimental groups of first-calf heifers, distributed according to milk yield, reproduction cycle duration (intercalving period – ICP), and the development of combined traits – milk production and reproductive capacity. The experimental group of cows was differentiated according to the average milk yield for the first lactation (9033 kg of milk) by a deviation of 0.67σ into three groups: animals with a milk yield <8423 (n = 68), with a milk yield of 8424-9642 (n = 158), and with a milk yield >9643 (n = 74). According to the duration of the reproductive cycle, they were differentiated by a deviation of 0.67σ from the average value of ICP = 384.4 days after the first calving into three groups: with a shortened duration (intercalving period "<373.4"; n = 72); average duration (intercalving period "373.5-395.3"; n = 151) and with prolonged reproduction cycle duration (intercalving period ">395.4"; n = 77). The control group of cows, based on the average milk yield during the first lactation (8.521 kg of milk), was differentiated by a deviation of 0.67σ into three groups: animals with a milk yield of <7943 kg (n = 71), with a milk yield of 7944-9097 (n = 157), and with a milk yield of >9098 (n = 72). According to the average value of the reproduction cycle of 386.5 days: animals with a shortened duration, taking into account 0.67σ, had an intercalving period of 375.6 days or less (n = 74); average duration – 375.7-397.3 (n = 156) and with an extended reproduction cycle duration – >397.4 (n = 70). The $\chi 2$ (chi-square) criterion was used to determine the conformity of the distribution of animals into three groups to the patterns of normal distribution (Pidpala *et al.*, 2012).

The test animals were divided into four groups based on the combination of deviations in the plus (1) and minus (2) directions from the average value of milk yield and reproductive capacity: 1-1, 1-2, 2-1, 2-2 (Pidpala *et al.*, 2012). The research materials were processed using statistical methods (Kramarenko *et al.*, 2019), in particular, the determination of the arithmetic mean ($\bar{X}$), the error of the arithmetic mean (*Sx*), the standard deviation (σ), coefficient of variation (*Cv*) to conduct a comparative analysis of the studied traits between the experimental and control groups and to establish the influence of different conditions of keeping and feeding on the productivity of Holstein heifers during their calving period. During the keeping of the experimental animals at the industrial complex and throughout all manipulations with them, the provisions of Law of Ukraine No. 249 (2012) and the European convention for protection of vertebrate animals used for experimental and other scientific purposes (1986) were observed.

RESULTS AND DISCUSSION

Observations have shown that the cows ate the complete monomix (total mixed ration) most intensively immediately after milking. Therefore, the fresh total mixed ration was distributed after removing feed residues from the feed table while the animals were in the milking parlor. Thus, the maximum level of consumption of a complete monomix was achieved, calculated as 28.2 kg of dry matter per head (experimental group) and 27.3 kg (control group), which contributed to high productivity in first-calf heifers during their calving period. It was found that under different conditions of comfort, in particular in a mega-barn with a controlled microclimate and in a pavilion-type barn with natural ventilation, the cattle in the experimental and control groups differed in terms of milk yield and lactation intensity in the first half of lactation (Table 2).

Table 2. *Characteristics of lactation intensity in first-calf Holstein cows divided into groups according to their milk yield in the first lactation*

Indicator	Research group		
	Parameters		
	$\bar{X} \pm Sx$	σ	Cv,%
Cows with milk yield <8423 (n = 68)			
Milk yield per 100 days of lactation, kg	3221.6 ± 11.27	11.3	3.0
Period until peak lactation, days	101.6 ± 1,15	1.2	9.6
Milk yield on the peak lactation day, kg	35.9 ± 0,60	0.6	14.2
Cows with milk yield 8424-9642 (n = 158)			
Milk yield per 100 days of lactation, kg	3008.5 ± 9,63	9.6	3.9
Period until peak lactation, days	116.0 ± 0.46	0.5	4.8
Milk yield on the peak lactation day, kg	37.0 ± 0.34	0.3	11.4

Table 2, Continued

Research group			
Indicator	Parameters		
	$\bar{X} \pm Sx$	σ	Cv,%
Cows with milk yield >9643 (n = 74)			
Milk yield per 100 days of lactation, kg	3003.4 ± 11.40	11.4	3.3
Period until peak lactation, days	121.9 ± 0.93[2,1]	0.9	6.7
Milk yield on the peak lactation day, kg	36.4 ± 0.34	0.3	8.1
Average across the entire selection (n = 300)			
Milk yield per 100 days of lactation, kg	3058.3 ± 8,20***	8.2	4.6
Period until peak lactation, days	114.1 ± 0,61	0.6	9.2
Milk yield on the peak lactation day, kg	36.6 ± 0.24*	0.2	11.4
Control group			
Indicator	Parameters		
	$\bar{X} \pm Sx$	σ	Cv,%
Cows with milk yield <7943 (n = 71)			
Milk yield per 100 days of lactation, kg	2956.0 ± 6.19	52,2	1.8
Period until peak lactation, days	113.7 ± 0.72	6.0	5.3
Milk yield on the peak lactation day, kg	35.7 ± 0.64	5.4	15.0
Cows with milk yield 7944-9097 (n = 157)			
Milk yield per 100 days of lactation, kg	2953.2 ± 4.98	61.4	2.1
Period until peak lactation, days	114.2 ± 0.55	6.8	5.9
Milk yield on the peak lactation day, kg	35.4 ± 0.39	4.8	13.5
Cows with milk yield >9098 (n = 72)			
Milk yield per 100 days of lactation, kg	2961.8 ± 7.01	59.5	2.0
Period until peak lactation, days	113.4 ± 0.62	5.2	4.6
Milk yield on the peak lactation day, kg	35.5 ± 0.60	5.1	14.4
Average across the entire selection (n = 300)			
Milk yield per 100 days of lactation, kg	2955.0 ± 11.65	131.8	4.5
Period until peak lactation, days	113.8 ± 0.93	10.5	9.2
Milk yield on the peak lactation day, kg	35.5 ± 0.37	4.2	11.9

Note: *$\bar{X}$ – arithmetic mean; Sx – arithmetic mean error; σ – standard error; Cv – coefficient of variation; *– p < 0.05; ***- p < 0.001 compared to the control group; 1 – p < 0.05; 2 – p < 0.001 compared to groups "<8423" and "8424-9642"*

Source: *compiled by the authors*

In terms of milk yield in the first 100 days of lactation, cows in the experimental group prevailed, which indicates the suitability of the technological environment, comfort of keeping, and adequacy of feeding to their biological needs during the intense period of milk production in the body of lactating animals. It was found that the average milk yield for 100 days of lactation in cows in the experimental group was 103.3 kg (p < 0.001) or 3.5% higher than in animals in the control group, which is explained by the comfort of their housing and the sufficiency of feeding with a general mixed diet from the feeder trays. As for the period before the peak of lactation, no significant difference was found between the experimental and control groups, as the difference was 0.7 days or 0.6%. Milk yield on the peak day of lactation was 1.1 kg (p < 0.05) or 3.1% higher in cows in the experimental group than in their peers in the control group. By determining the intensity of lactation in the first half of lactation in cows with different milk yields per lactation, it was found that high-yielding cows with a milk yield >9643 in the experimental group were characterised by a longer period before the peak of lactation, which was 121.9 days. The difference compared to groups "<8423" and "8424-9642" was 20.3 (p < 0.001) and 5.9 (p < 0.001) days, respectively, i.e., they reached the highest milk yield earlier, followed by a gradual decline. A similar tendency was not observed in the control group during the period before the peak of lactation. Regardless of the level of milk yield during the first lactation, the animals reached the peak of lactation on average at 113.4-114.2 days.

A comparative analysis showed that cows with a milk yield of <8423 in the experimental group had a 7.3% higher milk yield per 100 days of lactation than their highly productive counterparts. However, their milk yield per lactation was 7776 kg of milk, since after reaching the highest daily milk yield on the peak day of lactation, there was a rapid decline. The studied

traits, such as milk yield per 100 days of lactation and the period before the peak of lactation, were characterised by low coefficients of variation in both the experimental (Cv = 3.0-9.6%) and control (Cv = 1.8-9.2%) groups, while milk yield on the peak day of lactation was characterised by medium coefficients of variation (Cv = 11.4-14.2% and Cv = 11.9-15.0%, respectively), which indicates the combined influence of environmental and genetic factors on the development of this trait. The exception is high-yielding cows with milk yield >9643 in the experimental group, which are characterised by a low coefficient of variation. Thus, with a similar feed background but different comfort levels, in particular in a mega-barn with an artificially controlled microclimate, the individual characteristics of high-yielding Holstein cows are manifested. That is, in a mega-barn, the comfort of the technological environment meets the biological needs of lactating cows to the fullest extent possible and contributes to the manifestation of individual genetic predispositions for high productivity in the Holstein breed. Conversely, in a pavilion-type barn with natural ventilation, no such ability to develop productive traits in animals has been established. Studies of lactation intensity in the first half of lactation in cows from the experimental and control groups, distributed according to the duration of the reproductive cycle, revealed a difference in milk yield per 100 days and on the peak day of lactation (Table 3).

Table 3. *Characteristics of lactation intensity in first-calf Holstein cows with different reproductive cycle periods*

Research group			
Indicator	Parameters		
	$\bar{X} \pm Sx$	σ	Cv,%
Group of cows with ICP duration <373.4 (n = 72)			
Milk yield per 100 days of lactation, kg	3068.9 ± 18.56***	157.4	5.1
Period until peak lactation, days	114.3 ± 1.11	9.4	8.2
Milk yield on the peak lactation day, kg	36.5 ± 0.46	3.9	10.6
Group of cows with ICP duration 373.5-395.3 (n = 151)			
Milk yield per 100 days of lactation, kg	3057.8 ± 10.55***	129.7	4.2
Period until peak lactation, days	113.9 ± 0.9	11.1	9.7
Milk yield on the peak lactation day, kg	36.6 ± 0.35**	4.2	11.6
Group of cows with ICP duration >395.4 (n = 77)			
Milk yield per 100 days of lactation, kg	3049.5 ± 17.24***	151.3	5.0
Period until peak lactation, days	114.2 ± 1.20	10.5	9.2
Milk yield on the peak lactation day, kg	36.5 ± 0.50	4.4	12.0
Control group			
Indicator	Parameters		
	$\bar{X} \pm Sx$	σ	Cv,%
Group of cows with ICP duration <375,6 (n = 74)			
Milk yield per 100 days of lactation, kg	2974.9 ± 14,54	125.1	4.2
Period until peak lactation, days	115.9 ± 1.12	9.6	8.3
Milk yield on the peak lactation day, kg	36.0 ± 0.43	3.7	10.4
Group of cows with ICP duration 375.7-397.3 (n = 156)			
Milk yield per 100 days of lactation, kg	2942.2 ± 11,25	138.7	4.7
Period until peak lactation, days	114.0 ± 0.87	10.7	9.4
Milk yield on the peak lactation day, kg	35.3 ± 0.32	4.0	11.3
Group of cows with ICP duration >397.4 (n = 70)			
Milk yield per 100 days of lactation, kg	2955.9 ± 15.18	127.0	4.3
Period until peak lactation, days	112.4 ± 1.26	10.5	9.4
Milk yield on the peak lactation day, kg	35.8 ± 0.43	3.6	10.2

Note: ***– $p < 0.01$; ***– $p < 0.001$ compared to the control group; $\bar{X}$ – arithmetic mean; Sx – arithmetic mean error; σ – standard error; Cv – coefficient of variation*

Source: *compiled by the authors*

In the experimental group, animals with shortened, average, and prolonged inter-lactation periods had a 94.0 kg ($p < 0.001$) or 3.2% higher weight gain over 100 days; 115.6 kg ($p < 0.001$) or 3.9% and 93.4 kg ($p < 0.001$) or 3.2% higher than in their peers of similar distribution in the control group. The increase in milk yield on the peak day of lactation in cows of the experimental group of the above distribution by the duration of the reproductive cycle compared to the animals of the control group was 0.5 kg; 1.3 kg ($p < 0.01$) and

0.7 kg, respectively, which was 1.4%, 3.7% and 2.0% higher. According to such an indicator as the duration of the period before the peak of lactation, no significant differences were found between the distribution groups in the experimental and control groups. Therefore, it can be noted that Holstein cows are prone to a prolonged reproductive cycle, and the peak day of lactation occurs on the 112th-116th day of lactation. For the characteristics describing lactation intensity in the first 100 days, low and medium variability indices were established in the groups distributed according to the duration of the reproductive cycle. In first-calf cows with shortened, average, and prolonged intercalving periods in both the experimental and control groups, low coefficients (*Cv* = 4.2-9.7% and *Cv* = 4.2-9.4%, respectively) indicated a negligible influence of the environment on their manifestation. Such a trait as milk yield on the peak day of lactation in the specified distribution groups was characterised by a medium degree of variability (*Cv* = 4.2-9.7% and *Cv* = 10.2-11.3%, respectively), which indicated the influence of environmental factors on its manifestation.

As a result of investigating lactation stress in cows classified according to a combination of characteristics (milk yield and reproductive capacity), it was established that in the experimental group, cows in groups 1-1 and 1-2 differed in higher milk yield over 100 days of lactation, a longer period before reaching peak lactation, and milk yield on the peak day of lactation compared to their peers of similar distribution in the control group (Table 4). The differences were 33.6 kg; 1.9 days; 1.1 kg and 102.9 kg. ($p < 0.001$); 6.9 days ($p < 0.001$); 1.7 kg ($p < 0.05$), respectively. This manifestation of the studied characteristics in the animals of the experimental group is explained by the comfort of their maintenance in a mega-barn and proper feeding with a mixed diet from feeder trays, which ensured continuous free access to the consumption of monomix.

Table 4. *Characteristics of lactation intensity in first-calf Holstein cows in groups according to a combination of characteristics*

Research group						
Group by combined characteristics	Milk yield per 100 days of lactation, kg		Period before peak lactation, days		Milk yield on the peak lactation day, kg	
	$\bar{X} \pm Sx$	Cv,%	$\bar{X} \pm Sx$	Cv,%	$\bar{X} \pm Sx$	Cv,%
1-1 (n = 78)	3016.6 ± 14.06	4.10	117.6 ± 1.02	7.60	37.1 ± 0.44	10.50
1-2 (n = 63)	3022.2 ± 14.50***	3.8	118.6 ± 1.10***	7.5	36.1 ± 0.50*	9.9
2-1 (n = 55)	3138.3 ± 20.30	4.8	107.9 ± 1.60	10.9	35.8 ± 0.60	13.1
2-2 (n = 104)	3069.3 ± 14.40	4.8	112.0 ± 0.90	8.6	36.9 ± 0.40	12.0
Control group						
Group by combined characteristics	Milk yield per 100 days of lactation, kg		Period before peak lactation, days		Milk yield on the peak lactation day, kg	
	$\bar{X} \pm Sx$	Cv,%	$\bar{X} \pm Sx$	Cv,%	$\bar{X} \pm Sx$	Cv,%
1-1 (n = 69)	2983.0 ± 14.73	4,1	115.7 ± 1.17	8.4	36.0 ± 0.43	10.0
1-2 (n = 62)	2919.3 ± 16.98	4,6	111.7 ± 1.52	10.7	34.4 ± 0.51	11.8
2-1 (n = 58)	2955.9 ± 17.33	4,5	116.3 ± 1.16	7.6	35.9 ± 0.56	12.0
2-2 (n = 111)	2951.3 ± 12.95	4,6	113.3 ± 1.01	9.4	35.8 ± 0.34	10.0

Note: **– $p < 0.05$; ***– $p < 0.001$ compared to the control group; $\bar{X}$ – arithmetic mean; Sx – arithmetic mean error; σ – standard error; Cv – coefficient of variation*

Source: *compiled by the authors*

A similar trend in milk yield variability over 100 days of lactation was established for groups distributed according to combined traits, indicating the influence of genetic factors. The reduced influence of heredity on the trait of milk yield on the peak day of lactation is indicated by the coefficients of variability of the experimental and control groups. Thus, according to the distribution by combined traits (milk yield and reproductive capacity), the animals in the experimental group, which were kept in a mega-barn with the most comfortable technological environment for maintaining their welfare and high productivity, had an advantage in the studied indicators. The results show an increase in milk productivity in Holstein cows kept in a mega-barn with a complete mixed diet. These conclusions prompt a discussion on the impact of various factors on the realisation of the genetic potential of specialised dairy cattle breeds to increase the competitiveness and profitability of the dairy industry. The study proves the prospects and feasibility of introducing cross-ventilated and microclimate-controlled premises for dairy cattle in industrial milk production complexes, which will contribute to the creation of a comfortable environment, the maintenance of animal welfare, high productivity, and an increase in gross milk production.

An increase in milk yield was determined in the first half of lactation by 3.5% and on the peak day of lactation by 3.1% in cows kept in a mega-barn with a controlled microclimate and fed a complete monomix containing 28.2 kg of dry matter per head. These findings are consistent with the research of S.H. Pishchan & K.A. Sylychenko (2021), which showed that feeding cattle a pre-calculated diet that included food supplements containing vitamins, minerals, and compound feed generally satisfied their energy needs. The high energy content of the feed mixture in the diet of milking and newly calved Swiss cows during the autumn-winter calving period contributed to milk yields of 3539.6-3570.0 kg of milk during the first 100 days of lactations I-III. Many factors influence the vitality and productivity of dairy cattle, but among them the most significant are the environment, genetics, and biological needs of animals. The results of studies by H. Atashi *et al*. (2021) showed that the age of insemination of heifers affects the stability of lactation in first-calf heifers. They found a higher rise in the lactation curve and its subsequent rapid decline after reaching peak productivity in animals that calved for the first time at an older age. The study showed that heifers inseminated at an early age after calving were characterised by a lower but more stable lactation curve. A.S. Kramarenko *et al*. (2022) argued that the productivity of dairy cattle depends on a number of different factors, including genotypic and paratypic ones, but at the same time, feeding remains the most important among them, as it determines the success of any livestock industry, as evidenced by a comprehensive assessment of the characteristics of intensive milk production technology.

In a study by A. Kitaieva *et al*. (2024), cows were fed a single feed according to a developed diet, which included corn silage, alfalfa haylage, alfalfa hay, molasses, compound feed (corn, wheat, brewers' spent grains, sunflower oilcake, soybean oilcake), salt, chalk, premix for dairy cows, sodium bicarbonate, and monocalcium phosphate. For better consumption of the monofeed, 7.0 l of water per head was added to the feed mill. In both studies, Holstein cows showed high productivity when fed a complete diet. The average daily milk yield for the group of cows in the first 100 days of lactation was 32.1 kg, which is 7.0% higher than the planned yield, and in this study, it was over 35 kg. According to D. Mundan *et al*. (2020), the daily milk yield in Holstein cows ranged from 26.2 to 27.4 kg, and these figures were lower than the results of the current study of the daily milk yield of cows in the experimental group by 23.7-27.0% and in the control group by 26.2-23.2%. M. Gaworski & P. Kic (2024) evaluated production technologies on dairy farms in terms of animal comfort and welfare, which is ensured by free access to feed and reduced competition between animals in the resting area. In uninsulated high-capacity barns with natural ventilation, the comfort of dairy cattle is achieved through air movement using fans, spraying the cows' bodies, and high-pressure mist (evaporation) to cool the surrounding air, which also minimises the effect of solar radiation. D. Sreekumar & V. Sejian (2024) emphasised the importance of cow comfort, which includes the environment, in particular ventilation temperature, continuous access to feed and drinking water, and well-organised rest with sufficient lying space. Both studies emphasised the creation of comfortable conditions and the maintenance of animal welfare through the maintenance of an optimal microclimate, the avoidance of heat stress, and, most importantly, not only free and constant access to feed, but also its freshness and availability. The authors also note that high-volume premises should be used for dairy cattle housing.

C. Kipp *et al*. (2021) and R. Bleizgys *et al*. (2023) noted that one of the most important conditions for keeping cows is ensuring the necessary microclimate parameters in the barn. At the same time, an increase in temperature and humidity in the room can cause heat stress, which negatively affects the physiological state and productivity and even worsens the quality of milk produced. Similar conclusions were made in studies by A. Shevchenko & O. Petrenko (2020) and C.B. Tucker *et al*. (2021), who pointed out that it is impossible to achieve maximum productivity without creating conditions that comply with hygiene and veterinary and sanitary standards. Unfavorable conditions, such as poor ventilation, insufficient air exchange, heat, and rain, deteriorate the air and cause microbial contamination, while increased temperature and humidity worsen the microclimate. According to K.D.M. Frigeri *et al*. (2023), dairy cattle barns should be monitored for thermal conditions to reduce the harmful effects of heat stress, which will help increase milk production, improve milk quality, ensure herd health, and improve cow comfort. As noted, heat stress leads to sudden changes in the health and productivity of dairy cows. Studies have shown that in a barn with an artificially controlled microclimate, air circulation creates an optimal microclimate with the desired temperature, reduces gas accumulation in the room, and cools the animals in the rest area during the summer. The comfort of the technological environment contributes to the well-being of dairy cattle and high milk productivity. Thus, the technology of keeping dairy cattle in a mega-barn maximally meets the biological needs of milking cows, minimises heat stress, and contributes to the realisation of the genetic potential of high productivity of the Holstein breed.

CONCLUSIONS

Studies have shown that loose housing of Holstein cows in a mega-barn with an artificially controlled microclimate provides the most comfortable technological environment and contributes to maintaining their welfare. It was determined that in terms of the composition of different types of feed, the general mixed diet was similar and satisfied the biological needs of highly productive cows in the first half of lactation, based on dry matter consumption per head of 28.2 kg (experimental group) and 27.3 kg (control group), taking into account their productivity, lactation period, and body condition. It has been proven that with a similar feed background but different comfort levels, in particular in a mega-barn with an artificially controlled microclimate, the individual genetic predisposition of Holstein cows to high productivity manifests itself. In a pavilion-type barn with natural ventilation, such an ability to develop productive traits in animals has not been established. The average milk yield per 100 days of lactation in cows of the experimental group was 103.3 kg ($p < 0.001$) or 3.5% higher than in animals of the control group.

A comparative assessment of lactation stress in the first half of lactation in groups classified by milk yield, reproduction cycle duration, and combined traits determined the comfort of keeping cows in a mega-barn and the feasibility of feeding Holstein cows a mixed diet from feeder trays. In the experimental group, animals with shortened, average, and prolonged intercalving periods had milk yields per 100 days that were 94.0 kg ($p < 0.001$) 115.6 kg ($p < 0.001$) and 93.4 kg ($p < 0.001$) higher than in their peers of similar distribution in the control group. A study of lactation intensity in cows distributed according to combined characteristics found that the experimental first-calf heifers in groups 1-1 and 1-2 differed in higher milk yield per 100 days of lactation, a longer period before reaching peak lactation, and milk yield on the peak day of lactation compared to their peers of similar distribution in the control group. The difference was 33.6 kg; 1.9 days; 1.1 kg and 102.9 kg ($p < 0.001$); 6.9 days ($p < 0.001$); 1.7 kg ($p < 0.05$), respectively. Prospects for further research include expanding the list of economically useful traits and studying their manifestation in Holstein cows during three lactations under mega-barn conditions.

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CONFLICT OF INTEREST

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Технологічне середовище і годівля дійних корів за умов утримання в крос-корівнику

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Анотація. Молочне тваринництво є однією з найважливіших галузей тваринництва, оскільки забезпечує населення необхідними продуктами харчування та сировиною для підприємств з переробки молока. Дослідження мало на меті вивчити, як умови утримання та годівлі повними мономіксами впливають на рівень молочної продуктивності первісток голштинської породи в перший період лактації. Тварини експериментальної групи утримувалися в крос-корівнику з контрольованим мікрокліматом, а тварини контрольної групи – в корівнику павільйонного типу з природною вентиляцією. Було проаналізовано інтенсивність лактації в першій половині, і встановлено, що у корів експериментальної групи надої за 100 днів і в піковий день лактації були відповідно на 103,3 кг ($p < 0,001$) і 1,1 кг ($p < 0,05$) вищими, ніж у тварин контрольної групи. Аналіз показав, що корови в експериментальній групі з високою продуктивністю (>9643 кг) мали довший період досягнення піку лактації. Цей показник перевищував тривалість аналогічного періоду у корів з груп з продуктивністю «<8423» та «8424-9642» відповідно на 20,3 ($p < 0,001$) та 5,9 ($p < 0,001$) днів. Крім того, в експериментальній групі корови зі скороченим, середнім і подовженим репродуктивним циклом мали вищу молочну продуктивність протягом перших 100 днів лактації – на 94,0 кг ($p < 0,001$), 115,6 кг ($p < 0,001$) та 93,4 кг ($p < 0,001$) відповідно, порівняно з їхніми однолітками в контрольній групі з подібним розподілом тривалості циклу. Підсумок результатів за комбінованими показниками показав, що тварини в експериментальній групі продемонстрували кращі виробничі та фізіологічні характеристики порівняно з контрольною групою. Таким чином, утримання корів голштинської породи в крос-корівнику забезпечує комфортні технологічні умови, що відповідають біологічним потребам у першій половині лактації, мінімізують тепловий стрес і сприяють реалізації генетичного потенціалу високої продуктивності. Матеріал актуальний для тваринників і технологів у галузі виробництва молока на промислових комплексах

Ключові слова: голштинська порода; утримання корів; лактація; молочна продуктивність; репродуктивна здатність