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INFLUENCE OF PARATYPICAL FACTORS ON MILK PRODUCTION IN UKRAINE

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Abstract

The article presents data on the influence of paratypical factors on the milk productivity of dairy cows in different regions of Ukraine on farms with different methods of keeping animals - tethered and loose ones. In order to more accurately determine the impact, a multi-criteria analysis was conducted by 10 indicators. When comparing untethered and tethered methods of keeping dairy cows, the advantage of the loose method was revealed; its objective function according to the considered criteria was the smallest one of 0.1391. This indicator appeared to be 1.1553–5.3394 times worse for the tethered method. Also, to establish the correlation between paratypical factors - daily yield of standardized milk, diet overall nutrition value, crude protein content, undegradable protein content, daily ambient temperature and air humidity, mathematical models were developed and analyzed: linear, incomplete quadratic and full quadratic ones.

Key words*: mathematical model, method of animal keeping, milking cows, multi-criteria analysis, paratypical factors.*

INTRODUCTION

Ukraine's integration into the EU and the WTO encourages the production of dairy and meat products that are competitive and at the same time safe for the life and health of the population.

This is an impetus for the improvement of production technologies in accordance with international standards in the direction of reducing the impact of negative factors on the animal production level, stress resistance to technological and natural factors, and resistance to diseases.

Milk productivity of cows depends not only on genetic factors, physiological state, but also on environmental conditions. Most scientists rightly believe that when working with dairy cattle populations, it is necessary to take into account the influence of both genotypic and paratypical factors in specific economic conditions (Sklyarenko, 2018; Voitenko et al., 2019; Vedmedenko, 2019).

Of the latter, feeding and housing conditions are the most influential.

Feeding is a factor that determines the vital activity of animals. The productivity level, reproductive qualities, health and ultimately the economic and breeding value of livestock directly depend on the level and completeness of feeding. The use of innovative methods of preparing fodder for feeding allows not only to increase the productivity of cows, but also improves ruminal digestion, has a positive effect on their health and productive longevity (NRC, 2001; Popkov et al., 2018; Podobied et al., 2020; Erickson & Kalscheur, 2020).

The conditions and methods of keeping have no less effect on milk productivity. Loose keeping is considered more progressive, but in Germany almost 30% of dairy cows are kept on a tether, in the USA almost 60% of dairy farms had cowsheds with a tethered stall (Popescu et al., 2013). Very often this is caused by economic considerations, lack of space, equipment, convenience of service, especially in small and medium-sized operations. At the same time, when cows are kept loose, there are fewer leg, neck, and skin injuries (Beaver et al., 2021), as well as better fertility (Sawa & Bogucki, 2011).

MATERIALS AND METHODS

The objective of the research was to determine the paratypical factors on the milk productivity of dairy cows in different regions of Ukraine on farms with different methods of keeping animals - tethered and loose ones.

The research was conducted on a number of experimental farms incorporated in the system of the National Academy of Agrilcutltural Sciences of Ukraine (NAAS): State Experimental Farm Gontarivka of the Institute of Animal Science of the NAAS, Kharkiv region; State Experimental Farm Shevchenkivske, Kyiv region; State Experimental Farm Askaniyske, Kherson region (tethered and loose keeping); State Experimental Farm Ivanivka, Chernihiv region, State Experimental Farm Named After Decembrists, Poltava region, as well as on Private Agricultural Enterprise Pechenizke, Kharkiv region.

With the tethered keeping, cows were walked daily on the farm grounds on all the farms.

During the experiments, the following parameters were taken into account:

- the actual chemical composition and nutritional value of feed determined according to standard methods in the Laboratory for Evaluation of Animal Feed and Products of the Institute of Animal Science of the NAAS;
- actual feed consumption determined every ten days, with control feedings being applied during two consequent days, by determining the difference between the amount of feed given and feed remained for each group;
- level of cow milk yield determined monthly by conducting control milkings with further milk sampling to determine its quality;
- results of milk analysis performed to determine chemical composition, nutritional and energy values, physical and technological properties using the Bentley-150 infrared milk analyzer;
- ration cost;
- ambient temperature and air humidity determined every ten days during two consequent days;
- statistical processing of research results carried out by biometric methods.

Diets were balanced by all limited organic and mineral nutrients according to Ukrainian detailed feeding allowances (Bohdanov, 2013) according to cow milk yield taking into account actual feed chemical composition and nutritional value.

The research was conducted in the winter period on farms with different methods of cow keeping to determine the following values: daily ration costs per cow in Ukrainian hryvnias; daily milk yield per cow, kg; diet total nutrition value, MJ; feed consumption per kg of milk, MJ; diet crude protein content, g; diet undegradable protein content, g; milk protein percentage; milk fat percentage; costs per liter of milk, Ukrainian hryvnias (UAH); profit gained per cow, UAH.

Methodological approaches of multi-criteria analysis involve obtaining an estimate of the distance-to-target integral criterion under the influence of paratypical factors in the production of livestock products. The distance-to-target integral criterion is obtained using the approach of collapsing all values of paratypical factors through normalization and obtaining one value of the integral criterion (Piskun et al., 2020).

Using the MATLAB program, models of correlation between paratypical factors and standardized milk yield surface of response model were developed.

RESULTS AND DISCUSSIONS

The obtained research results are presented in Table 1.

When comparing loose and tethered methods of keeping dairy cows using the multi-criteria analysis, the advantage of the loose method was revealed; its objective function according to the considered criteria was the smallest one of 0.1391 (Table 2).

This value for the tethered method appeared to be 1.4486 times worse in State Experimental Farm Askaniyske, 1.1553 times worse in Shevchenkivske, 1.4537 times worse in State Experimental Farm Gontarivka, 5.3394 times worse in State Experimental Farm Ivanivka, 1.5112 times worse in State Experimental Farm named after Decembrists and 1.6499 times worse in Private Farm Pechenizke.

Table 1. Data to determine dairy cow milk productivity for different methods of livestock keeping

Indicator	Name of the farm						
	Askaniiske	Askaniiske	Shevchenkivske	Gontarivka	Ivanivka	named after Decembrists	Pechenizke
	Method of keeping animals						
	loose	tethered					
Ration costs per cow/day, UAH	98.01	98.01	103.52	87.03	66.64	98.06	90.21
Diet total nutritional value, MJ	225.60	225.60	229.70	223.90	157.00	219.20	245.00
Feed consumption per kg of milk, MJ	8.21	10.48	8.27	8.64	13.1	11.39	11.89
Crude protein, g	3144	3144	3461	3216	2290	3267	3505
Undegradable protein, g	765	765	848	717	550	825	981.6
Daily milk yield per cow/day, kg	27.78	21.52	27.76	25.9	12	19.25	20.62
Protein percentage	3.15	3.15	2.9	2.87	2.95	3.21	3.11
Fat percentage	3.62	4.13	3.61	3.99	3.75	3.82	3.93
Cost of 1 liter of milk, UAH	4.24	4.80	6.22	6.99	8.05	5.67	6.12
Profit gained per cow, UAH	168.2	149.58	185.3	162.5	56.49	200.63	123.98

Table 2. Multi-criteria analysis of dairy cow productivity according to different methods of livestock keeping

Indicator	Name of the farm						
	Askaniiske	Askaniiske	Shevchenkivske	Gontarivka	Ivanivka	named after Decembrists	Pechenizke
	Method of keeping animals						
	loose	tethered					
Ration costs per cow/day, UAH	1.5535	1.4708	1.5535	1.3060	1	1.4715	1.3537
Diet total nutritional value, MJ	1.0860	1.0860	1.0666	1.0943	1.5605	1.1177	1
Feed consumption per kg of milk, MJ	1	1.2765	1.0073	1.0524	1.5957	1.3874	1.4483
Crude protein, g	1.1149	1.1149	1.0128	1.0899	1.5306	1.0729	1
Undegradable protein, g	1.2832	1.2832	1.1576	1.3691	1.7848	1.1899	1
Daily milk yield per cow/day, kg	1	1.2909	1.008	1.0726	2.3150	1.4432	1.3473
Protein percentage	1.0191	1.0191	1.1069	1.1185	1.0882	1	1.0322
Fat percentage	1.1409	1	1.1441	1.0351	1.1014	1.0812	1.0509

Table 2 (continued)

Indicator	Name of the farm						
	Askaniiske	Askaniiske	Shevchenkivske	Gontarivka	Ivanivka	named after Decembrists	Pechenizke
	Method of keeping animals						
	loose	tethered					
Cost of 1 liter of milk, UAH	1	1.1321	1.4670	1.6486	1.8986	1.3373	1.4434
Profit gained per cow, UAH	1.1928	1.3413	1.0828	1.2347	3.5516	1	1.6183
$\sum U_k$	11.3904	12.0148	11.6066	12.0212	17.4264	12.1011	12.2941
$N(C_k)$	0.1391	0.2015	0.1607	0.2021	0.7426	0.2101	0.2294
Times	-	1.4486	1.1553	1.4537	5.3394	1.5112	1.6499

The conducted multi-criteria analysis showed (Table 3) that the best results were obtained in State Experimental Farm Shevchenkivske with the tethered method of keeping dairy cows, where the objective function according to the considered criteria was the smallest and was equal to 0.1420. This value was 1.3191 times worse in State Experimental Farm Askaniyske (tethered method), 0.0401 times worse in State Experimental Farm Gontarivka, 5.0648 times worse in State Experimental Farm Ivanivka, 1.3620 times worse in State Experimental Farm Named after Decembrists, 1.4895 times worse in Private Farm Pechenizke.

Table 3. Multi-criteria analysis of the productivity of dairy cows under the tethered method of keeping them

Indicator	Name of the farm					
	Askaniiske	Shevchenkivske	Gontarivka	Ivanivka	named after Decembrists	Pechenizke
Ration costs per cow/day, UAH	98.01	103.52	87.03	66.64	98.06	90.21
Diet total nutritional value, MJ	225.60	229.70	223.90	157.00	219.20	245.00
Feed consumption per kg of milk, MJ	10.48	8.27	8.64	13.1	11.39	11.89
Crude protein, g	3144	3461	3216	2290	3267	3505
Undegradable protein, g	765	848	717	550	825	981.6
Daily milk yield per cow/day, kg	21.52	27.76	25.9	12	19.25	20.62
Protein percentage	3.15	2.9	2.87	2.95	3.21	3.11
Fat percentage	4.13	3.61	3.99	3.75	3.82	3.93
Cost of 1 liter of milk, UAH	4.8	6.22	6.99	8.05	5.67	6.12
Profit gained per cow, UAH	149.58	185.3	162.5	56.49	200.63	123.98
$\sum U_k$	11.8726	11.4198	11.8206	17.1917	11.9339	12.1142
$N(C_k)$	0.1873	0.1420	0.1821	0.7192	0.1934	0.2115
Times	1.3191	-	0.0401	5.0648	1.3620	1.4895

Also to establish the correlation between paratypical factors of daily standardized milk yield, kg (Y) and total nutrition value of the diet, MJ (X_1); crude protein content, g (X_2); undegradable protein content, g (X_3); daily ambient temperature, °C (X_4); air humidity, % (X_5) mathematical models were developed and

analyzed: linear, incomplete quadratic and full quadratic ones.

The linear model has the following form:

$Y = -2.38687+0.21867*X_1 + 0.00772*X_2 - 0.04820*X_3 - 0.17269*X_4 - 0.07093*X_5$

Sample variance D = 13.35906

Figure 1 shows the standardized milk yield surface of response, kg (Y) to the total nutrition value of the diet, MJ (X_1) and the average daily ambient temperature, degrees C (X_4).

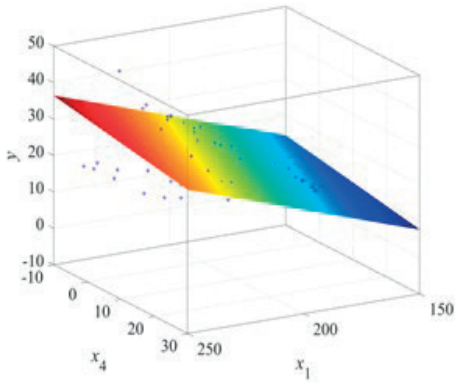

Figure 1. The standardized milk yield surface of response, kg (Y) to the total nutrition value of the diet, MJ (X_1) and the average daily ambient temperature, °C (X_4) (linear model)

The incomplete quadratic model has the following form:

$Y = -323.82746 + 1.23571*X_1 + 0.28351*X_2 - 0.46145*X_3 - 0.24459*X_4 - 0.39289*X_5 - 0.00249*X_1^2 - 0.00005*X_2^2 + 0.00029*X_3^2 + 0.00350*X_4^2 + 0.00228*X_5^2$

Sample variance D = 8.92430.

Figure 2 shows the standardized milk yield surface of response, kg (Y) to the total nutrition value of the diet, MJ (X_1) and the average daily ambient temperature, °C (X_4).

The complete quadratic model has the following form:

$$Y = -237.09235 + 1.26345*X_1 - 0.18096*X_2 + 0.93135*X_3 + 2.73535*X_4 + 1.34315*X_5 + 0.02508*X_1^2 + 0.00001*X_2^2 + 0.00104*X_3^2 + 0.01052*X_4^2 + 0.00036*X_5^2 - 0.00004*X_1*X_2 - 0.01418*X_1*X_3 - 0.04518*X_1*X_4 - 0.01968*X_1*X^5 + 0.00015*X_2*X_3 + 0.00081*X_2*X_4 + 0.00052*X_2*X_5 + 0.00516*X_3*X_4 + 0.00150*X_3*X_5 + 0.00438*X_4*X_5$$

Sample variance D = 2.78920.

Figure 3 shows the standardized milk yield surface of response, kg (Y) to the crude protein content (X_2) and the average daily ambient temperature, °C (X_4);

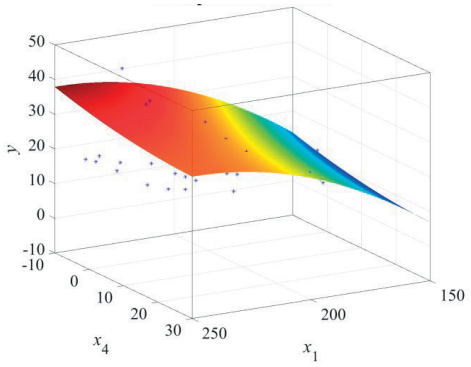

Figure 2. The standardized milk yield surface of response, kg (Y) to the total nutrition value of the diet, MJ (X_1) and the average daily ambient temperature, °C (X_4) (incomplete quadratic model)

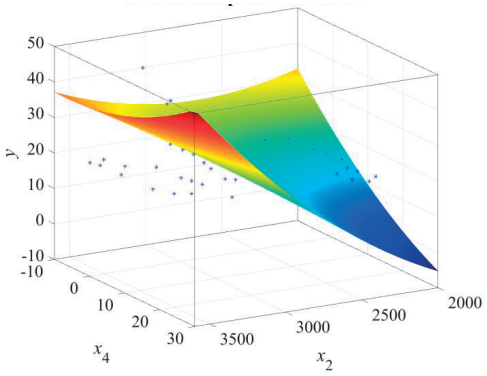

Figure 3. The standardized milk yield surface of response, kg (Y) to crude protein content (X_2) and average daily ambient temperature, °C (X_4) (full quadratic model)

The analysis of the obtained models shows that the sampling variance of the full quadratic model is the smallest, i.e., this model most adequately describes the correlation between paratypical factors.

CONCLUSIONS

According to the results of the multi-criteria analysis, the advantage of the untethered method of keeping dairy cows was established

as the objective function according to the considered criteria was the smallest one of 0.1391. Other options were 1.1553-5.3394 times worse.

Mathematical models of the effect of paratypical factors that included diet total nutrition value, crude protein content, undegradable in the rumen protein content, daily ambient temperature and air humidity on the standardized milk daily yield were developed. The full quadratic model most adequately describes the relationship between paratypical factors.

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TECHNOLOGIES OF THE AGRO FOOD PRODUCTS PROCESSING