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Dependences between the milk protein characteristics in cattle and offspring

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First of all, the quality of milk depends on zootechnical factors influencing its change in the cow's body formation. To improve the quality of milk, we need to establish the influence of these factors on milk components. One of the important factors that affect the indicators of protein content is the value of the mother according to these characteristics. The article considers the influence of the genetic factor (mother's productivity) on the indicators of protein content in milk and milk protein of their daughters. Studies have found that, according to the first lactation, the increase in the milk protein yield of daughters with an increase in the same indicator of mothers was much more intense compared to the second and third lactations. The degree of influence on the first lactation was 6.9%, on the second - 4.6%, on the third - 4.4%, on the average - 4.3%. Regarding the dependences of the protein content of mothers and daughters on the number of lactation, similar trends are observed as for the yield of milk protein. The degrees of influence are: for the first lactation - 3.9%, for the second - 1.0%, for the third - 0.2% and on the average - 2.3%. With increasing protein content and milk protein yield in mothers, the corresponding signs in daughters also increase. However, protein content and milk protein yield in mothers and daughters are not linearly related. We found the highest association between mothers' and daughters' productivity in animals with high productivity levels. In low-productivity animals, this connection is weakly expressed.
Keywords: cattle; milk; milk protein; lactation; degree of influence

Introduction

Today, dairy farming remains one of the leading sub-sectors of animal husbandry, and its development is important not only in ensuring the country's food independence but also in the social aspect (Palii, 2020).

In order to improve the breeds of dairy animals, create highly productive types and individual herds, economically valuable indicators of the breeding stock of specialized dairy breeds of the world's best gene pool are studied (Kozlova & Nazarenko, 2002; Palii et al., 2020a; Rodríguez-Bermúdez et al., 2019). The effectiveness of breeding work is determined by how the new generation of animals exceeds the original productivity (Carlos Bondan et al., 2019; Habtamu et al., 2018). Given the use of modern milk production technologies, increasing the productivity of dairy cattle is highly dependent on the use of high-yield cows (Paliy et al., 2021; Pidpala & Matashnyuk, 2019).

When improving breeds through another one, the effectiveness is judged only by the difference in productivity between the original breeds and their hybrids. However, under the same conditions of feeding and keeping animals, it is of great practical

interest to establish the advantage of daughters in productivity over mothers and its dependence on the level of productivity of the latter (Demchuk, 2002; Osipenko et al., 2018; Paliy, 2016). When mothers are selected by protein content, the advantage of their daughters is significantly reduced. The regression law can explain this pattern when highly productive mothers, less productive daughters than themselves, but better than animals characterized by population averages, are obtained (Gorbatenko & Gyl', 2006). However, according to the studies of foreign and domestic scientists (Dadousis et al., 2018; Kos et al., 2001; Kuczaj & Blicharski, 2001; Palii et al., 2020b; Seidel et al., 2020), the opinion was formed that highly productive animals most often are obtained from highly productive mothers, and they are themselves mothers of highly productive daughters.

To determine the size of the maternally inherited information realized in the offspring, Merkushyn (1992) analyzed herd data on the Simmental first-calf heifers, which comprised 511 mother-daughter pairs of three generations. They found that the average number in all the generations studied was 23.5-41.7%. However, the quality of the worst animals was realized more fully (52.8-71.4%). Determination of the influence on the offspring of more distant ancestors on the maternal line also showed that animals that descend from the best ancestors retain the ability to transmit the heritability of productive parameters. Cows that were not characterized by a high development of the studied indicator, but are descendants of the best animals, give more highly productive daughters than those descended from ancestors with lower productivity. Galushko (2011), when analyzing the primary selection and genetic parameters in terms of milk productivity and reproductive capacity of Holstein cows, found that the level of variation of traits for different lactations varied within the milk yield - 17-23%, the fat content in milk - 13.2-17.1%, protein content in milk - 7.4-8.9%, lactation duration - 18-25%. Also, the studies conducted by Sklyarenko et al. (2017) established the dependence of the milk production of cows on the productivity of their female ancestors.

Thus, the effect of selection is primarily influenced by maternal qualities. In most cases, it was found that with an increase in milk production in mothers, the corresponding characteristics of their daughters also increase.

Materials and Methods

During the research, the results of univariate analysis of variance of the mother's productivity on productive indicators were analyzed. The factor "mother's productivity" was used as the analyzed factor, and the protein content in milk and the yield of milk protein was used as the dependent factor. The analysis was performed using the General Linear Model - GLM General Factorial of the SPSS 16.0 computer standard statistical software package.

For each fixed factor, the standard indicators of the protein content in milk and milk protein yield were determined. These indicators were: the number of lactations (n), arithmetic mean (X), arithmetic mean error (S_x), and a standard deviation (σ). The power of these factors regards the protein content, and the yield of milk protein was determined. Quantitative factors were analyzed using the standard Table Curve - 2D software package. Methods of one-dimensional non-linear regression analysis were used to study the effect of quantitative factors on protein content and milk protein yield using the standard Table Curve - 2D software package. Equations were calculated for each factor, which described the dependence of the studied indicators. The resulting graphs, the dependence of the protein content and the yield of milk protein on the studied factors, were analyzed for adequacy, determinism, accuracy, and reliability according to M. A. Plochinskiy (1970) method.

The criterion for the accuracy of the description of actual data by the regression equations was the coefficient of determination R^2, which made it possible to estimate the total variance of the protein content and milk protein yield, which can be described using these equations. According to this criterion, out of 106 potential equations, we selected those that most adequately described the actual dependence of the protein content and the yield of milk protein on the studied parameters (mother's productivity). Equations with a confidence level of *P* less than 0.95 were excluded from the analysis. The coefficient of determination shows a numerical estimate of the variance of productive characteristics, which is due to the variance of the investigated factor (the so-called "explained" variance) (Afifi & Eisen, 1982). The simultaneous influence of several factors on the effective indicator was determined using a Two-Way Analysis of Variance.

Results and Discussion

The effectiveness of breeding work largely depends on how accurately and reliably the breeder can assess the genetic inclinations of the selected animals. One of the essential genetic factors that influence the indicators of protein content is the mother's value by these characteristics. To one degree or another, the studied genetic factor is conditional since the factor of mother's productivity has both genetic and environmental components.

Studies have examined the effect of milk protein content and mothers' milk protein yield on daughters.

When analyzing the protein content, it was revealed that 2.3% of the variability of the protein content was subject to description with a high degree of reliability P=0.999. The standard error of prediction was SE=0.1090% protein. The dependence between protein content in mothers and daughters for all available lactations is shown in Fig. 1.

The best equation to describe the relationship between mean protein content in mothers and daughters was $y=3.070+0.0051e^x$.

Analyzing the above graph of the dependence of the protein content of daughters and mothers, we found that with an increase in the studied indicator in mothers, it also increases in daughters. However, the degree of connection between these indicators increases with an increase in the protein content in mothers' milk. With an increase in the protein content in mothers' milk from 2.75% to 3.00%, one can expect an increase in the protein content in daughters' milk by 0.022%. Thus, with an increase in mothers' protein content from 3.50 to 3.75%, daughters' milk's protein content increases by 0.047%.

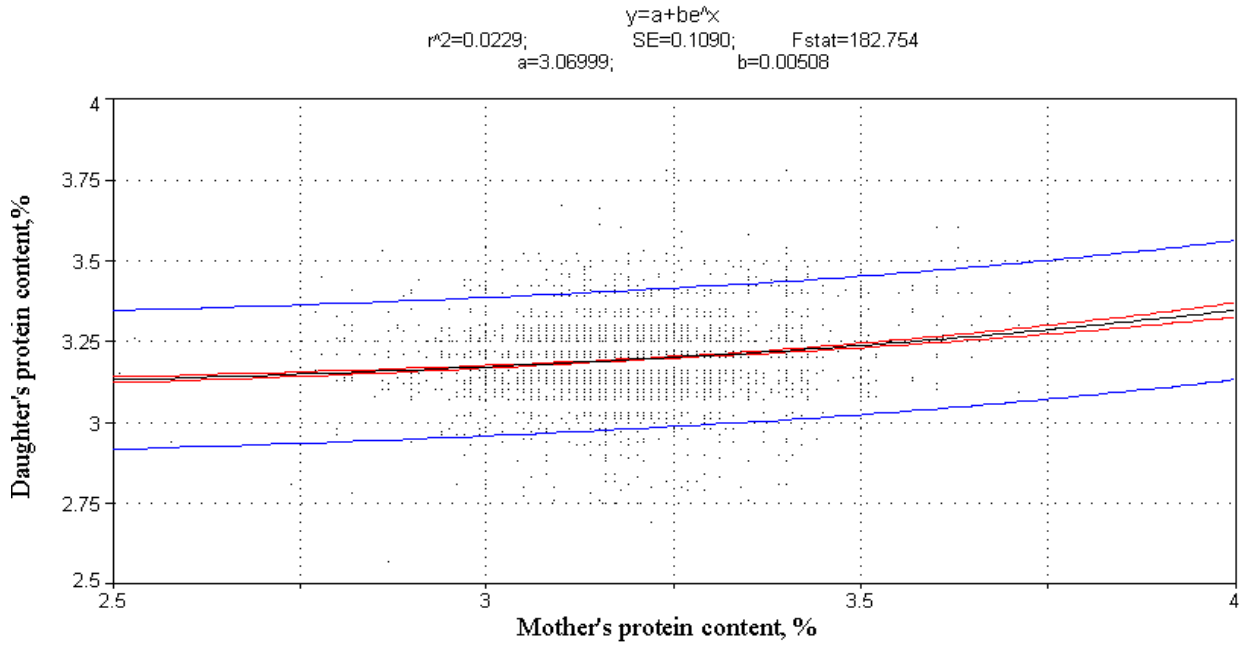

Fig. 1. Protein content in milk of daughters and mothers for all available lactations

The equation y=150.4+0.0006x2 most appropriately described the relationship between the milk protein yield of daughters and mothers. This equation describes 4.3% variability in milk protein yield (R^2=0,0428, P>0,999); the standard error of prediction was SE=43.059 kg of milk protein. The graph of this dependence of the average milk protein yield of daughters and mothers is shown in Fig. 2.

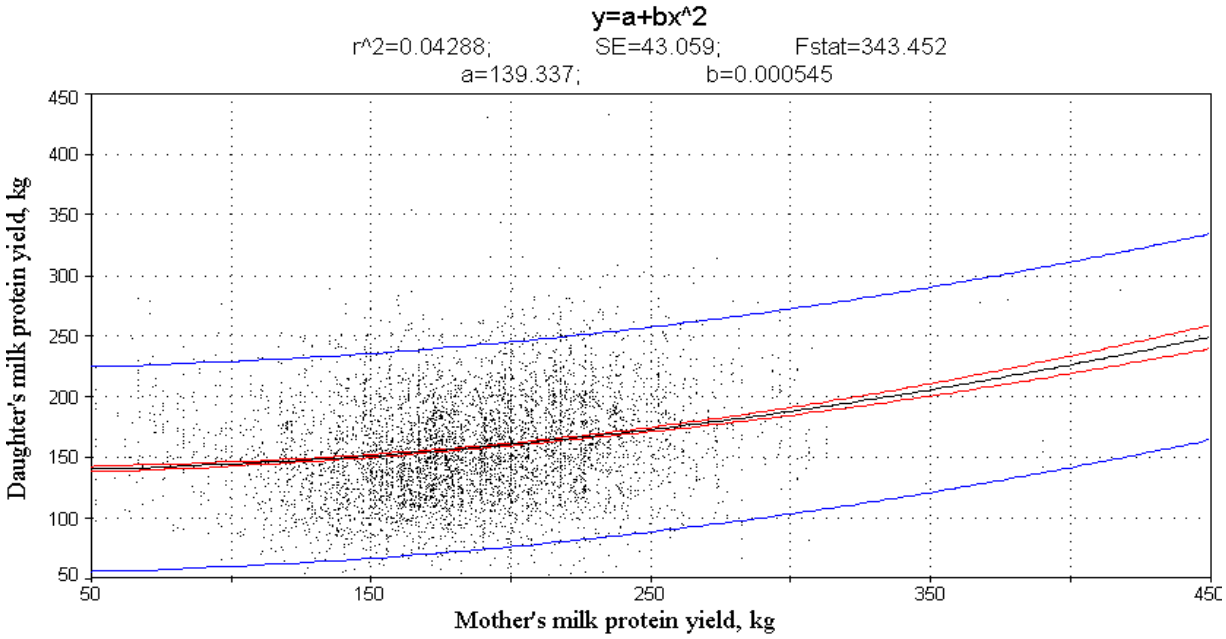

Fig. 2. An average yield of milk protein of daughters and mothers for all available lactations

In general, the tendency of the relationship is similar to that discussed above; the higher the average yield of milk protein in mothers, the higher it is in daughters. However, the nonlinearity of the dependence, in this case, is more clearly expressed. As a result, with an increase in mothers' yield of milk protein from 50 to 100 kg, we can expect an increase in these characteristics in daughters by 4.5 kg if the milk protein yield of mothers increases from 250 kg to 300 kg, the average milk protein yield of daughters will increase by an average of 16.5 kg.

After considering the average data on protein content and milk protein yield in general, we analyzed the relationship between these factors of mothers and daughters in the context of separate lactations. It was found that for the first lactation, the equation $y=3.020+0.0069e^x$ described this dependence regarding the protein content in milk most appropriately.

The presented equation describes 3.9% of the variability of the protein content in milk for the 1st lactation (R^2=0.039) with a standard error SE=0.140% and a degree of reliability P>0.999 (Fig. 3).

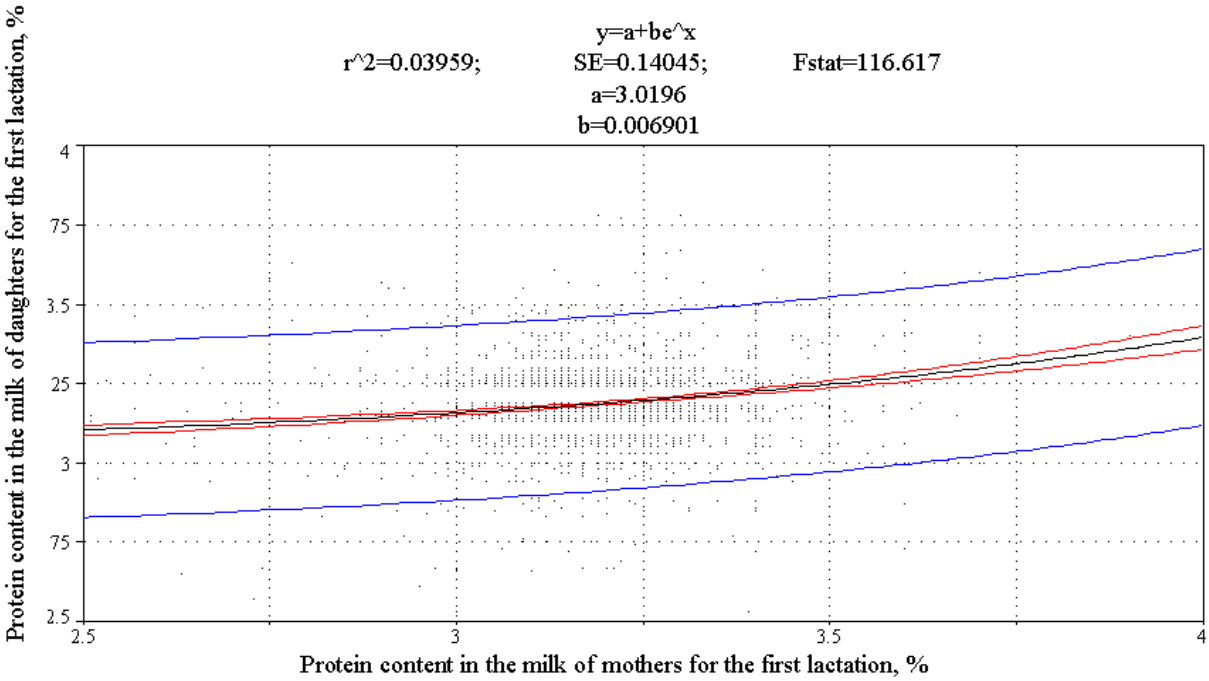

Fig. 3. The relationship between the protein content in the milk of mothers and their daughters for the 1st lactation

The increase in the protein content of the 1st lactation from 2.75% to 3.0% caused the 0.031% increase in daughters. In most animals, protein indicators for the first lactation range from 3.0% to 3.5%. When the level of protein content in the milk of mothers changes from the lower to the upper limit, an 0.051% increase in daughters can be expected, the equation y=128.05+0.0000033x3 most appropriately described the dependence of the milk protein yield of daughters and mothers in the first lactation. This equation stipulates 6.9% variability (R^2=0.0690) in the yield of milk protein for the first lactation; the standard error of prediction was SE=35.84, and the degree of reliability was P>0.999 (Fig. 4).

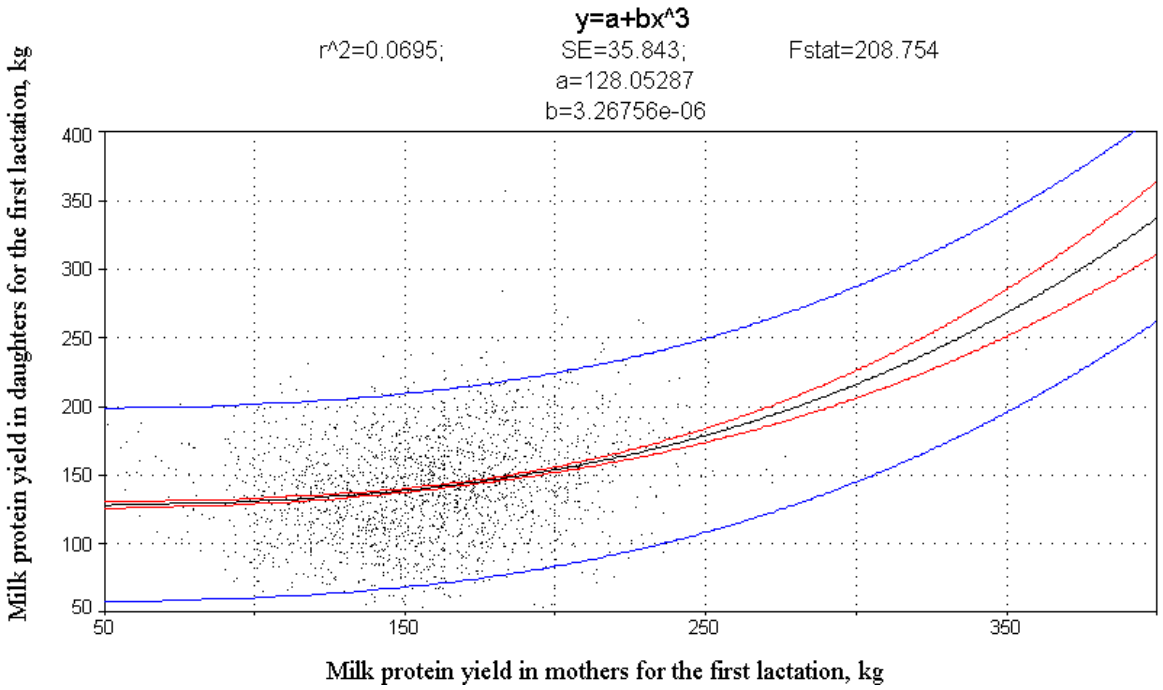

Fig. 4. The yield of milk protein of mothers and daughters for the 1st lactation

Figure 4 shows that the same pattern is observed when considering the above-described graphs. The non-linear dependence of the yield of milk protein in comparison with the protein content is more pronounced. With an increase in the mother's milk protein yield from 100 kg to 150 kg, from 150 kg to 200 kg, and from 200 kg to 250 kg, one can expect an increase in this indicator in daughters by 7, 13, and 22 kg, respectively.

In a comparative analysis of the relationship between the protein content in milk and the milk protein yield of mothers and daughters in the first, second, third, and middle lactations, one can state a positive non-linear relationship between them. However, for the first lactation, the increase in the milk protein yield of daughters with an increase in the same indicator of mothers was much more intense than the second and the third lactations.

The degree of influence for the first lactation was 6.9%, for the second one - 4.6%, for the third one - 4.4%, and on the average - 4.3%. Regarding the dependences of the protein content of mothers and daughters on the number of lactation, similar trends are observed as for the yield of milk protein. The degrees of influence are: for the first lactation - 3.9%, for the second - 1.0%, for the third - 0.2% and on the average - 2.3%.

Consequently, with an increase in the level of milk production, the relationship between the productivity of mothers and daughters increases. Thus, when calculating the coefficient of heritability for the studied characteristics, it is necessary to consider the average level of milk productivity of animals. It is advisable to use the latter's values in the calculations of the breeding effect, calculating their heritability coefficients for each level of productivity separately.

To establish a joint influence of the studied factor with other determining parameters on the protein content and milk protein yield, we carried out the dispersion analyzes of the joint influence of the indicators of milk protein production of mothers, and other studied factors (Table 1).

Table 1. The joint influence of the factor "mother's productivity" with the studied genetic and non-genetic factors

Factors	Protein content, %		Milk protein yield, kg	
	degree of influence,%	reliability level	degree of influence,%	reliability level
Mother's productivity	2.3	>0.999	4.3	>0.999
Father - Mother's productivity	4.0	>0.999	4.1	>0.999
Calving number - Mother's productivity	1.0	>0.999	0.5	>0.999
Breed combination - Mother's productivity	1.1	>0.999	1.3	>0.999
Month of caling - Mother's productivity	0.1	<0.950	0.2	<0.950
Feeding level - Mother's productivity	1.6	>0.999	0.1	>0.990
The level of concentrates in the diet - Mother's productivity	1.7	>0.999	0.1	>0.990
Breed - Mother's productivity	0.4	>0.999	1.6	>0.999

The table shows that the most influencing pair of factors was "father - mother's productivity". The degree of influence is practically the same in protein content and milk protein yield (with a difference of 0.1%), with a high degree of reliability. Thus, this line of research results again indicates the importance of selecting milk protein production, both on the maternal and paternal lines. The unreliable pair turned out to be "calving month - mother's productivity" and with a trim level of influence of 0.1-0.2%, respectively. Almost all other factors have a definite effect on both the protein content and the yield of milk protein. Thus, it has been established that such a factor as "mother's productivity" has a significant, both independent and joint with other factors, influence on the protein content and the yield of milk protein.

The degree of influence of the mother's productivity on the protein content is 2.3%, on the milk protein yield - 4.3%. The "father" factor exerts the most substantial joint effect of the protein content in mother's milk on the same indicator; the degree of influence is 4.0%, with a high level of reliability (P>0.999). The most significant joint influence on the yield of milk protein is exerted by factors - "father - mother's productivity", "breed combination - mother's productivity". These factors describe 4.1%, 1.3% variability in daughters' milk protein yield, respectively (P>0.999). For different lactations, equations have been developed that describe up to 3.9% of the variability of the protein content in milk and up to 6.9% the variability of the yield of milk protein based on the corresponding characteristics of mothers. We found that with an increase in protein content and milk protein yield in mothers, similar signs in daughters also increase. However, protein content and milk protein yield in mothers and daughters are not linearly related. The highest relationship between the productivity of mothers and daughters occurs when considering animals with a high level of productivity. In low-productivity animals, this relationship is weakly expressed.

In a comparative analysis of the relationship between the protein content in milk and the milk protein yield of mothers and daughters in the first, second, third, and middle lactations, one can state a positive non-linear relationship between them. However, for the first lactation, the increase in the milk protein yield of daughters with an increase in the same indicator of mothers was much more intense compared to the second and third lactations. The degree of influence for the first lactation was 6.9%, for the second - 4.6%, for the third - 4.4%, and on the average - 4.3%. Regarding the dependences of the protein content of mothers and daughters on the number of lactation, similar trends are observed as for the yield of milk protein. The degrees of influence are: for the first lactation - 3.9%, for the second - 1.0%, for the third - 0.2% and on the average - 2.3%.

The results obtained are consonant with the works (Azimova, 2018; Galushko, 2011; Paliy & Paliy, 2021). Thus, in the work of Azimova (2018), a comparative assessment of the milk productivity of daughters and their mothers shows that daughters surpass mothers in milk yield in 305 days of lactation. The protein content of daughters' milk is also higher than that of their mothers. Consequently, with an increase in milk productivity, the relationship between the productivity of mothers and daughters increases. The protein concentration in milk is also influenced by keeping cows and the technology of machine milking (Palii & Palii, 2019; Shkurko, 2005; Shortall et al., 2016). Non-compliance with the stereotype of milking is one of the causes of stressful situations, increased levels of adrenal cortex hormones, and adrenaline. As a result, there is a decrease in milk yield by 0.6-1.5 kg and protein - by 0.1%. Failure to follow the rules of machine milking leads to mastitis, which, in turn, disrupts the normal function of the mammary gland (Degen et al., 2015; Klaas & Zadoks, 2017; Palii et al., 2020c).

The breed of animals with a specific genetic potential has a significant influence on the chemical composition of milk and the yield of dairy products. The interbreed difference in protein content is due to genetic factors, i.e., each consolidated breed of

animals has a corresponding concentration of protein in milk (Palii et al., 2021). The intra-breed difference in protein content in cows' milk was also established, and it was proved that it is more significant than interbreeding by this characteristic (Maurmayr et al., 2018) that indicates the possibility of selection to improve livestock breeds by protein milk yield.

Conclusions

We found that the degree of influence of the mother on the protein content in milk of cows is 3.19%, on the yield of milk protein - 1.3%, with a high degree of reliability (P>0.999).
With increasing protein content and milk protein yield in mothers, the corresponding characteristics in daughters also increase. However, protein content and milk protein yield in mothers and daughters are not linearly related. We registered the highest association between mothers' and daughters' productivity in animals with high productivity levels. However, in low-productivity animals, this relationship was weakly expressed.

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