

## Preconditions for eco-friendly milk production on the modern dairy complexes

A.P. Paliy<sup>1</sup>, O.V. Nanka<sup>1</sup>, O.A. Naumenko<sup>1</sup>, V.G. Prudnikov<sup>2</sup>, A.P. Paliy<sup>3</sup>

<sup>1</sup>Kharkiv National Technical University of Agriculture named after Petro Vasylenko, Moskovsky Prospect, 45. of. 413, Kharkiv, 61050, Ukraine.

<sup>2</sup>Kharkiv State Veterinary Academy, Str. Academic 1, Mala Danylivka, Dergachi district, Kharkiv region, 62341, Ukraine.

<sup>3</sup>National Scientific Center «Institute of Experimental and Clinical Veterinary Medicine», Str. Pushkinska 83, Kharkiv, 61023, Ukraine. E-mail: [paliy.andriy@ukr.net](mailto:paliy.andriy@ukr.net)

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It has been established that the degree of contamination of the cows' udder and shin, which refers to Category I, does not affect the milk quality (according to the CFU, the milk refers to the grade "Extra"). With a further increase in the degree of contamination of the cows' udder and shin up to Categories IV and V, compared to Category I, the degree of mechanical contamination of the lavage from the udder increases correspondingly by 6.4 and 8.8 times at  $p < 0.001$ . The degree of bacterial contamination of milk is particularly significant-by 30.9 and 38.4 times ( $p < 0.001$ ), which causes its deterioration. Comparing the level of contamination of the udder of Category III to Category II, the difference by 1.7 times was established, and by the degree of bacterial contamination of milk-1.5 times, at  $p < 0.001$  in both cases. During the statistical analysis of the values of mechanical contamination of the udder and shin with the approach from Category I to Category IV, a high degree of probability was detected ( $p < 0.001$ ), and with the approach from Category IV to V, the difference in degree of contamination was 1.4 times, at  $p < 0.01$ . It has been proved that the increase in the degree of contamination of separate areas of the cows' body surface by the integrated 5-point assessment of the hygienic state of animals is accompanied by the increase in the quantitative values of mechanical contamination of milk and its bacterial contamination, which is confirmed by a high positive correlation dependence ( $r = +0.917$  and  $r = +0.934$ ). At the same time, it has been determined that the correlation coefficient has the highest value ( $r = +0.990$ ) between the integrated scoring assessment according to the categories of contamination of the cows' udder and shin, and the level of mechanical contamination of the lavages from the udder. Furthermore, it has been proved that the state of bacterial contamination of milk is affected by the degree of its mechanical pollution- $r = +0.945$  and the degree of contamination of the cows' udder ( $r = +0.957$ ).

**Keywords:** High yielding cows; lavage; milk quality; category; bacterial contamination

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### Introduction

Solving the problem of increasing the efficiency of dairy farming, increasing the volume of milk and dairy products production are closely linked with the strengthening and development of the forage base, as the main factor in the ecological system of production and the health of the dairy herd (Ghaid Al-Rabadi et al., 2018; Osipenko et al., 2018).

Side by side with this, the solution to the global problem of the lack of eco-friendly and high-quality raw milk is not only to increase the productivity of dairy cattle at the expense of the feeding factor, but also to optimize the existing production infrastructure (Paliy, 2016).

Dairy cows, especially high-yielding, are sensitive to the environmental impact of the ecosystem, which affects their health. In order to maintain the high quality of dairy products and reproduction of the stock, it is necessary to ensure the optimum conditions for keeping the livestock (Endres, 2017; Haley et al., 2000).

The availability of quick methods for assessing the hygiene of production, including that of the dairy stock, enables the localization of risks for effective sanitation and significantly improves the quality and ecological compatibility of milk (Sycheva, 2014; Paliy, 2018).

When cows are kept on the dairy complexes with paddocks and on pasture, the contaminating impurities of the animal's udder and body are mostly combinations of manure, urine, litter and soil, having different adhesion and cohesive properties (Borshch et al., 2017; Hvatova, 2016; Neja et al., 2017).

The need for sanitation of the cattle is determined visually, however, the conditions of placement of animals, location of the mammary gland and the speed of rotation complicate the survey. Thus, inspecting each cow individually, one can skip the

dirty teats. Existing methods for determining the level of cow hygiene do not provide a quick and reliable assessment of the health and hygiene status. They are complex in the assessment, material and special requirements for carrying out such analyzes (Galton et al., 1986; Paliy, 2016).

To control the technological processes in dairy cattle breeding, quantitative short-term microbiological control methods are required that provide real-time results and give an opportunity for quick and accurate assessment of hygiene (Gleeson et al., 2009; Magnusson et al., 2006). Therefore, the prospect of search, improvement and development of effective, variational and reliable methods of determining the quality of cow hygiene is an urgent issue both of scientific and practical interest (Gleeson et al., 2009; Magnusson et al., 2006). The prevalence of contamination of cows' body parts and its impact on their health, productivity and, first of all, on the quality of milk produced also have both scientific and practical interest. Many of the authors do not emphasize these individual factors, so an urgent need for conducting research of this nature arose. At the same time, the concentration of livestock on farms requires new approaches to assessing the conditions of stockkeeping and the sanitary and hygienic state of the body surface of high yielding animals, since these factors undoubtedly affect the quality and ecological compatibility of milk.

## Materials and methods

The aim of the scientific and economic experiment was to develop and implement a technological solution for a comprehensive assessment of the sanitary and hygienic status of high yielding cows with the perspective of the further production of ecologically pure milk on the complexes of industrial type. To detect the degree of animal contamination, special observations were made on two groups of cows, 65 heads in each.

At the next stage, the effect of mechanical contamination of the cow's udder and shin on the level of bacterial contamination of milk was investigated. The research was carried out in three groups of animals, 65 heads in each, subject to the use of the developed methodological approach (Patent № 109695).

The results of the research were processed by the method of variation statistics on the basis of the calculation of the arithmetic mean (X), the deviation of the indicators from the mean arithmetic error (SX) and the reliability of the difference between the comparable indicators (p).

## Results and discussion

Due to the fact that cow hygiene is closely related to the quality of milk, such as mechanical purity and bacterial contamination, its status allows us to assess the comfort of resting animals and the degree of effect of contamination on the milk quality.

As the result of a generalization of various methodological approaches to assessing hygiene factors in livestock farming, point system was determined to be the most commonly used. Thus, in foreign practice, to predict the morbidity of cows for mastitis, a method is used to evaluate the degree of contamination of the milk mirror of the cow udder, which is carried out before milking on an automatic plant of the "Parallel" type. In this case, the score of 1 point is obtained by the cows with a clean milk mirror (no surface contamination). In case of contamination of the area of the milk mirror up to 10%-the cows receive 2 points, in the range from 11% to 30%-3 points, and more than 30%-4 points (Ingawa et al., 1992). But this technique does not take into account the contamination of other parts of the animal's body and its impact on the quality and ecological compatibility of milk.

In this regard, it was necessary to develop a comprehensive methodological approach to assessing cow hygiene, which could answer about their impact on qualitative indicators of milk.

Complex assessment of hygiene is a group assessment, and an increase in this indicator by one point may increase the number of somatic cells in milk by 50000/ml.

For the purpose of operative integrated assessment of cow hygiene, a method has been developed that is carried out as follows: the cows come into the milking parlor and occupy their places, a rectangular stencil of 30×30 cm size, in which the element of the filtered calibrated paper is installed, is raised to the udder [State Standard 12026-76. Laboratory filter paper. Specifications]. Then this stencil contacts the surface of the udder.

On the next stage rectangular stencils of 30 × 30 cm size, in which the element of the filtered calibrated paper is installed [State Standard 12026-76. Laboratory filtered paper. Specifications] contact he lower part of the rare limb (from ankle joint downwards).

Then, by the amount of dirt left on the filtered calibrated paper, cow hygiene is classified by five positions of degree of contamination. Interpretation of the data received is carried out according to the Table 1.

**Table 1.** Integrated point assessment of cow hygiene.

Cat ego ry	Degree of contamination of udder and shin	of	The area of contamination of the filtered calibrated paper element which contacted the udder, %	The area of contamination of the filtered calibrated paper element which contacted the shin, %
I	Pollution is absent	-		<20
II	Light degree of contamination	-		20-30
III	Medium degree of	<25		31-50

	contamination		
IV	High degree of contamination	25-30	51-70
V	Severe contamination	31-40	71-90

The classification by categories of contamination of the filtered calibrated paper element assumes the following: Category I-pollution on the filter element that was in contact with the udder is absent, and the filter element that came in contact with the shin has a contamination on the area of <20%; Category II-the filter element that was in contact with the udder is clean, and the filter element that was in contact with the shin has a contamination of 20-30% of the area; Category III-the filter element that was in contact with the udder has a contamination on the area of <25%, and the element that was in contact with the shin has a contamination of 31-50% of the area; Category IV- the filter element that was in contact with the udder is contaminated by 25-30%, and the element that was in contact with the shin is contaminated by 51-70%; Category V-the filter element that was in contact with the udder is contaminated by 31-40%, and the filter element that came in contact with the shin has a pollution of 71-90% of the area.

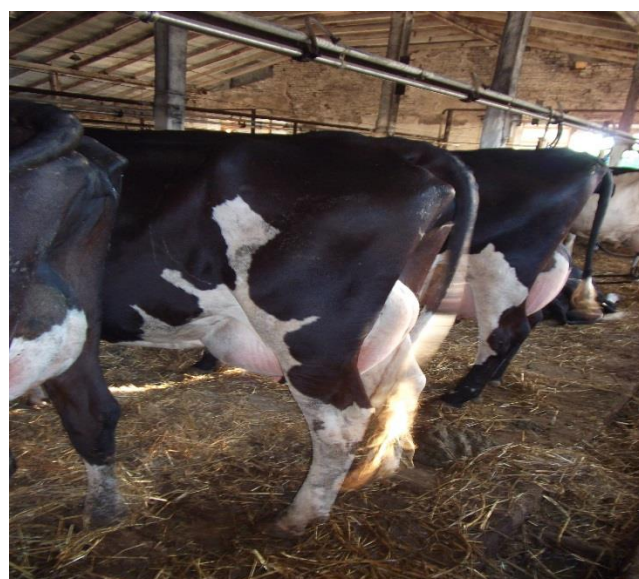
The correlation coefficient between the integrated point assessment of the contamination of the cows' udder and shin by the area of contamination of the calibrated filter paper element has the magnitude  $r=+0.933$ .

Thus, the integrated point assessment of cow hygiene according to the innovative methodological approach is estimated on a scale of the categories from I to V on the udder (the front and the back of the udder, the base and the teats) and in the lower part of the hind limbs (from ankle joint downwards, including hooves).

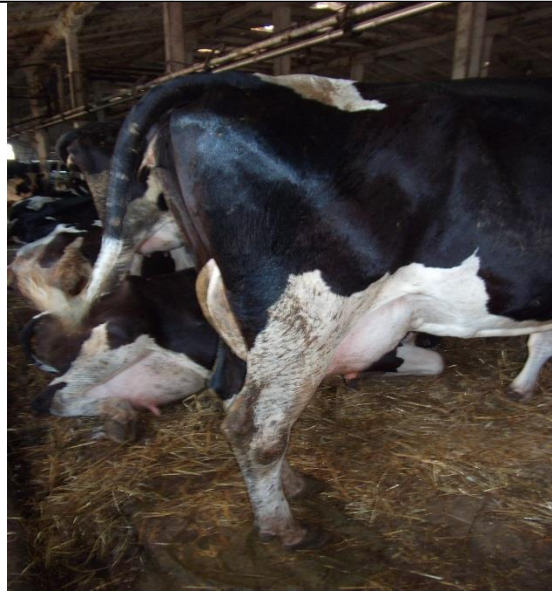
Special monitoring of the contamination of the cows' udder and shin on the dairy complexes has made it possible to note the presence of contamination in accordance with the developed 5-point classification by categories (Figures 1-5).



**Figure 1.** The cow hygiene refers to category I.



**Figure 2.** The cow hygiene refers to category II.



**Figure 3.** The cow hygiene refers to category III.



**Figure 4.** The cow hygiene refers to category IV.



**Figure 5.** The cow hygiene refers to category V.

Additionally, it can be claimed that if the cows receive an estimate of categories III-V (Figures 3-5), it is necessary to identify and eliminate the source of contamination, as the indicated assessment is a warning that there is a breach of the cow maintenance technology.

The application of the developed integrated assessment of cow hygiene provides quantitative values for their mechanical contamination by both the group of cleanliness and the conditional specific particle of contamination. But it is extremely

important to have the information and to determine the relationship between the degree of mechanical contamination of the cows' udder and the shin and the degree of bacterial contamination of the surface of these areas and the milk.

In this regard, the possibility of assessing the purity and hygienic quality of cow milk, depending on the degree of contamination of these areas of the animals' body was verified in the production conditions.

The analysis of the results of the study of the degree of mechanical contamination of the udders and shins, as well as bacterial contamination of milk (CFU) of the cows that had contaminated body parts by the categories, according to the developed scale, allowed to determine the average numerical values of these indicators and their correspondence to the milk State Standard 3662:2015 (Table 2).

**Table 2.** Effect of contamination of cows' udder and shin on qualitative indicators of milk, ( $X \pm S_x$ ).

Category	Number of samples, n	Mechanical pollution, mg/l		CFU of the milk, ths./cm <sup>3</sup>	Milk grade according to the State Standard 3662:2015
		Lavage from the udder and shin	Milk		
I	12	20.0 ± 1.53	0.6 ± 0.14	89.0 ± 10.0	"Extra"
II	12	45.0 ± 2.41***	1.8 ± 0.15	256.0 ± 15.0***	Top grade
III	12	77.0 ± 3.20	3.2 ± 0.16	385.1 ± 21.0	1 <sup>st</sup> grade
IV	12	128.0 ± 8.20***	7.4 ± 0.35	2754.0 ± 98.0***	2 <sup>nd</sup> grade
V	12	175.1 ± 12.46***	14.6 ± 0.85***	3415.0 ± 385.0***	Out of grade

**Note:** \*\*-p<0.01; \*\*\*-p<0.001.

It was established that the degree of contamination of the cows' udder and shin, which is classified in Category I, does not affect the quality of milk (according to the CFU, the milk refers to the grade "Extra").

With a further increase in the degree of contamination of the cows' udder and shin up to Categories IV and V, compared to Category I, the degree of mechanical contamination of the lavage from the udder increased correspondingly by 6.4 and 8.8 times at p<0.001 in both cases. The degree of bacterial contamination of milk is particularly significant-by 30.9 and 38.4 times (p<0.001), which causes its deterioration. Comparing the level of contamination of the udder of Category III to Category II, the difference by 1.7 times was established, and by the degree of bacterial contamination of milk-1.5 times, at p<0.001 in both cases.

Thus, the milk obtained from the cows classified by the level of contamination of the udder and shin to Category I, corresponded to the grade "Extra", and from those of Categories IV and V to the 2<sup>nd</sup> grade and out of grade, respectively.

Thus, during the statistical analysis of these values of mechanical contamination of the udder and shin with the approach from Category I to Category IV, a high degree of probability was detected (p<0.001), and with the approach from Category IV to V, the difference in degree of contamination was 1.4 times, at p<0.01.

Regarding the mechanical contamination of milk, the evaluation by all the categories showed the probability of p<0.001.

For a more detailed study of the relationship between the variables examined, the coefficients of correlation were determined. Thus, analyzing the results of the research carried out, a high positive correlation between the contamination of the cows' udder and shin was determined by the point assessment by categories and the mechanical contamination of the lavages from the udder and the milk of these animals, as well as the bacterial contamination of milk (Table 3).

**Table 3.** Correlation dependencies (r) of the point assessment according to the degree of contamination of the cows' udder and shin to the degree of mechanical contamination and bacterial contamination of the milk.

Indicator	Correlation coefficient
Integrated point assessment by categories of contamination / the degree of mechanical contamination of the lavage from the udder	0.99
Integrated point assessment by categories of contamination / the degree of mechanical pollution of the milk	0.934
Integrated point assessment by categories of contamination / CFU of the milk	0.917
The degree of mechanical contamination of the lavage from the udder / the degree of mechanical pollution of the milk	0.97
The degree of mechanical contamination of the lavage from the udder / CFU of the milk	0.957

The increase in the degree of contamination of separate areas of the cows' body surface by the integrated 5-point assessment of the hygienic state of animals is accompanied by the increase in the quantitative values of mechanical contamination of milk and its bacterial contamination, which is confirmed by a high positive correlation dependence ( $r=+0.917$  and  $r=+0.934$ ).

It has been established that, the correlation coefficient has the highest value ( $r=+0.990$ ) between the integrated point assessment according to the categories of contamination of the cows' udder and shin, and the level of mechanical contamination of the lavages from the udder.

At the same time, it has been proved that the state of bacterial contamination of milk is affected by the degree of its mechanical pollution- $r=+0.945$  and contamination of the cows' udder ( $r=+0.957$ ).

Thus, the studies conducted using the developed methodological approach to the integrated assessment of cow hygiene proved the hypothesis of a close correlation and direct dependence of qualitative ecological indicators of milk on the degree of bacterial and mechanical contamination of the udder and shin, which causes the necessity and expediency of use of the developed method in production.

Because of the introduction of domestic and foreign technologies, the issue of environmental factors affecting the quality of milk and the search for new methods for its improvement remains poorly studied (Kitikov et al., 2017; Paliy, 2017).

The drawn milk already contains from several hundred to several thousand bacteria per 1 ml. Bacteria enter it directly in the mammary gland via the duct channel-secretory contamination.

Milk obtained during milking, is always subject to bacterial contamination from the environment-post-secretory contamination. The level of post-secretory contamination of milk is conditioned by the conditions of keeping cows, the environment in which they are kept, the state of the inventory, which is in contact with milk, and also depends on the observance of hygiene norms and rules by the personnel involved in the receipt and processing of milk (Gibson et al., 2008).

A clean, healthy skin of animals contains a relatively small number of microorganisms that are "residents" which even perform a protective function as antagonists of other, more dangerous, microorganisms. A contaminated skin has a large number of different microorganisms. The main source of microorganism contamination of the skin is the animal's excrements, 1 g of which contains dozens of billions of microorganisms: lactic acid bacteria, coliform bacteria, butyric acid bacteria, putrefactive bacteria and enterococci (Grindal et al., 1989).

Another, not less important source of the animal's skin contamination, and then milk, can be a litter material. Particularly dangerous are spoiled hay and straw, in which sporogenous putrefactive and butyric bacteria, yeasts and mould occur in large quantities (McKinnon et al., 1990).

Consequently, the main factors influencing the contamination of the cows' body are the technological factors associated with the modes of application and quality of the bedding material, the methods of removal of manure from the premises, as well as from the paddocks. Therefore, the quality and environmental friendliness of the milk depends to a certain extent on the indicated technological parameters as the main factors influencing the sanitary and hygienic condition of high yielding cows (Lefevre et al., 2010; Nanka et al., 2018; Paliy et al., 2018).

The contamination of the animals' body surface is known to be influenced by the season of the year, because the cows are on paddocks for a certain time and are prone to external environmental factors. When the cows are kept in boxes, such factors do not affect their contamination, because the animals spend all year round in the premises, and their degree of contamination is regulated by modes for the timely removal of manure and litter application only (Latysheva, 2016; Paliy, 2015).

But it is extremely important to have information and to determine the relationship between the degree of mechanical contamination of the cows' udder and shin and the level of bacterial contamination of the surface of these areas and the milk. In this connection, the possibility of assessing the purity and hygienic quality of cow milk was tested, depending on the degree of contamination of these parts of the animals' body.

As a result of the research conducted it has been established that one of the main factors of improving the quality of milk may be the reduction of the cows' body contamination. During the examination and inspection of animals for their contamination, it was found that the degree of contamination of certain parts of the body was irregular as a result of violation of the modes of animals handling, which must ensure the cleanness of their bodies, the contamination of certain parts of the body occurs, especially that of the rare part.

## Conclusion

The V-point comprehensive cow hygiene assessment system has developed as a tool for assessing and controlling of the level of hygiene on dairy farms, finding problem areas and analyzing for the improvement of the environmental situation.

Increasing the degree of contamination of certain areas of the cows' body surface according to the V-point integrated assessment of hygiene is accompanied by an increase in the quantitative values of mechanical contamination of milk and the level of its bacterial contamination, and, accordingly, a decrease in its grade, which is confirmed by a high positive correlation between the integrated score of hygiene and level of mechanical contamination of milk ( $r=+0.934$ ) and bacterial contamination ( $r=+0.917$ ) at  $p < 0.001$  in both cases, indicating the need for tighter control over the observance of the technology of dairy cows keeping.

The hypothesis of the close correlation and the direct dependence of the qualitative parameters of milk on the degree of contamination of the cow's milk ( $r=+0.957$ ) and the level of mechanical contamination of the udder ( $r=+0.970$ ) has been

confirmed, which determines the necessity and expediency of using the techniques to predict the quality of the milk produced under industrial conditions.

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