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Milking and udder health assessment in industrial farming

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The safety and environmental purity of milk is determined by the total bacterial contamination, the indicators of which depend on the sanitary and hygienic state of production, the technical equipment of the enterprise, culture and discipline of production. It was established that milk with 1 point has the number of microorganisms of 87.0±8.0 × 10^3 per 1 cm^2, which corresponds to the "Extra" quality (de luxe). When assessing the contamination of teats of II points, the number of microorganisms increased by 2.8 times, compared to I point teats - 246.0±16.0 × 10^3 per 1 cm^2. At the same time the milk met the requirements of the top grade. The samples of milk of cows with contamination of teats of III points contained microorganisms in the amount of 378.0±47.0 × 10^3 per 1 cm^3, which is 291 thous. per 1 cm^3 CFU more than in samples of I point) and the milk refers, accordingly, to the first grade. The milk with the assessment of IV points had the bacterial contamination of 2668.0±85.0 × 10^3 per 1 cm^3, which is 7 times more than in that of III points. According to these data, the milk samples met the requirements of the second grade. The milk with the assessment of V points had 1.3 times higher bacterial insemination, compared to that of IV points. A positive correlation was found between the contamination of cow's teats according to the point assessment and bacterial contamination of the milk (r = +0.919). There was also a high correlation between contamination of the lavages from cow's teats and bacterial contamination of the milk (r = +0.947).
Keywords: highly productive cows, hygiene, lavage, milk quality, bacterial contamination, microorganisms

Introduction

The industrial production of high quality, environmentally pure milk puts forward new exclusive standards for the technological features of the industry. In recent years, there has been an exacerbation of a number of problems in industrial dairy cattle breeding, along with the general increase in the intensity of production. First and foremost, it is the production of low-grade milk, an increase in cases of mastitis in dairy cattle, an increase in labor and energy costs per unit of output (Palii & Palii, 2019; Petrov et al., 2016; Szyda et al., 2019). To overcome these negative trends, it is required to develop new technologies and technical solutions to create optimal conditions for the milking process at dairy complexes. The quality of products manufactured is one of the main prerequisites for the efficient functioning of production due to the rational use of economic resources. The concept of product quality is thought of as its property or properties that satisfy certain or expected needs of consumers (Sycheva, 2014). At the same time, attention is paid to the formation of product characteristics even before the stage of its production, which implies the feasibility of managing activities to ensure a certain level of product quality.

Thus, nowadays the issue of improving the quality of milk is also relevant. After all, there are a variety of factors affecting it: the conditions of keeping the animals, the milking procedure, the quality of milking equipment, its washing, the use of appropriate detergents, storage and transportation of milk (Kitikov & Romaniuk, 2017; Paliy et al., 2019; Sklyar et al., 2017). As a result of violation of technological and sanitary-hygienic standards of milk production, its microbial contamination and mechanical pollution take place, which can lead to its spoilage and, as a result, make the milk unsuitable for further processing. In order to prevent these negative factors, it is necessary not only to be well aware of technological issues related to the keeping, servicing of animals and equipment, but also to introduce the latest advances in the science of animal husbandry production technology in order to produce high quality

products in sanitary and environmental terms (Hvatova, 2016; Paliy, 2016). All this is not possible without a thorough knowledge of the theory that is required for the proper implementation of milk production and effective measures to improve its quality.

The milk of cows of different breeds varies by mass fraction of fat and size of fat balls, by mass fraction of protein, fractional composition of casein and size of casein micelles (Osipenko et al., 2018). Milk composition and its synthesis in the mammary gland are influenced by factors related to animal feeding. When animals are underfed by 30% compared to the norm, the mass fraction of solids in milk is reduced by 0.7-0.9%, including fat - by 0.4 and protein - by 0.3%. Feeding animals with a balanced diet of nutrients, minerals and biologically active substances according to their live weight, productivity and needs provides not only a large amount of milk, but also a relatively higher content of fat, solids, proteins and other components. Such milk tastes good, has a fresh smell and optimum physical and mechanical properties (Palii et al., 2019a; Zucali et al., 2015).

Also, certain types of feed, the intervals between feeding and milking, the presence and the chemical composition of aromatic and flavoring substances in feed have a certain effect on the composition and properties of milk. Thus, the quality of coarse and juicy feed causes changes in the taste and aroma of milk. It is believed that milk with feed defects may contain up to 22 chemical compounds, the major ones being acetone, butanol, ethanol, propanol, isopropanol and ethyl acetate. The most common are silage smell and taste of milk. The undesirable odor and taste of the silo appear when silo is incorrectly fermented and such a smell is caused by the presence of esters, alcohols, aldehydes and ketones. The degree of expressiveness of the silage odor and the taste of milk are influenced by the moisture content of the silo, its good quality, ventilation in the room at the time of feeding (Shkromada et al., 2019; Soltani, 2017).

According to the data (Hadzevych et al., 2019) change in the initial properties of milk as a result of bacterial processes is possible only when the number of microorganisms is more than 200 thous. Per 1 cm^3 and clearly manifested in the number of microorganisms more than 1 mln. per 1 cm^3. Therefore, it is the permissible level of different groups of microorganisms in milk which is crucial. Microbial contamination is also affected by the level of general health of the animals on farm, the hygiene of the skin of animals, especially the breast, and, ultimately, the personal hygiene of the staff involved in the process of milk production and processing (Bava et al., 2017; Gleeson et al., 2009; Paliy, 2017).

The main sources of increasing bacterial contamination of the milk in the process of milking cows are the skin (hair) and animal udder. It has been found that, with poor udder treatment before milking, up to 67% of mechanical contaminants and 32% of bacteria enter the milk from the tips of the teats (Doyle et al., 2015; Palii et al., 2019b). Sanitary hygienic treatment of udder before milking with the use of means for its purifying, being an integral part of the process of preparation of cows before milking, allows to remove dirt from the udder and, thereby, reduce the possibility of mechanical pollution and bacterial contamination of milk and prevent the possibility of transfer of milking mastitis from one animal to another (Gibson et al., 2008; Ingawa et al., 1992; McKinnon et al., 1990; Paliy, 2019).

Trends in the growth of the requirements to milk quality call for improvements in the process of its obtaining and revising a number of scientific provisions for the production of high quality products, while moving to more stringent regulations for determining its quality indicators (Velazquez-Ordonez et al., 2019). At the same time, the solution to the global problem of the lack of environmentally pure and quality raw milk is not only to increase the productivity of dairy cattle due to the factor of feeding, but also to optimize the existing production infrastructure, which will allow to increase the terms of productive use of cows and to realize their genetic potential fully (Palii et al., 2020; Weir et al., 2016).

Quantitative rapid microbiological control methods are needed to manage technological processes in dairy cattle, which give real-time results and allow for rapid and accurate hygiene assessment (Magnusson et al., 2006; Neja et al., 2017). Therefore, the prospect of finding, improving and developing operational, variational and reliable ways of determining the quality of cow hygiene is an urgent problem both of scientific and practical interest.

Material and methods

The purpose of the scientific and economic experiment was to develop a technological solution to determine the degree of contamination of teats of high-yielding cows and its impact on the level of bacterial contamination of milk. The experiment consisted of several stages. In the first stage, in order to detect contamination of the teats, special observations were made on six groups of cows with 65 heads each. In the next stage, a method for expert evaluation of the sanitary-hygienic condition of the surface of the udder of high-yielding cows was developed on the basis of patent search and experimentally grounded initial data were obtained. Further the effect of the degree of mechanical pollution of the cows' udder of on the level of bacterial contamination of milk was investigated. The studies were performed on three groups of animals, each with 65 heads.

The next stage was the development of a technological solution for assessing the cleanliness of teats by microbial index in accordance with the developed methodological approach to determine the sanitary-hygienic state of the surface of poles of the udder of highly productive cows. When determining the quality of milk we were guided by the requirements of current regulations: the sampling was carried out in accordance with the National Standard of Ukraine ISO 707:1997; the number of microorganisms was determined according to the National Standard 7357:2013 and the National Standard IDF 100B:2003; the amount of coliforms - in accordance with the international standard GOST 30518-97 and National Standard IDF 73A:2003 on the Endo's medium. Total bacterial milk contamination was investigated by a method based on the properties of mesophilic aerobic and optional anaerobic microorganisms to multiply on a dense nutrient agar at a temperature of 30±1 °C for 72 hours.

The system of technological methods, to ensure the accuracy of measuring the quality of milk, included the sampling of raw milk, the use of modern instrumental methods and the development of rapid methods for determining the quality of milk and confirm the accuracy of their measurement. When developing of the point scale, the gradation was determined depending on the task, the required accuracy, promptness of the results and the ability to interpret the characteristics of quality levels and purity indexes. To determine the quality of milk the device 'Ecomilk' KAM 98-2A No. 271001/04 according to Standards GOST 23453-90 and GOST 30518-97 was applied. It was used to analyze the quality indicators of milk composition. The amount of milk required for analysis was 25 cm^3.

The results of the studies were processed by the method of variational statistics based on the calculation of arithmetic mean (X), deviation from the arithmetic mean error (S_X) and the reliability of the difference between the compared indicators (p). Data processing were performed using Microsoft Excel software.

Results and discussion

As a result of observations of the contamination of the cows' udder teats (6 groups by 65 heads) in different seasons on the dairy complexes 5 most characteristic manifestations of their contamination, which allowed the distribution of animals by the degree of contamination and its conditional assessment in points from I to V were determined (Figs. 1-5).

Fig. 1. Impeccably clean udder teats, I point

Fig. 2. Udder teats without pollution, II points

Fig. 3. Udder teats with minimal pollution, III points

Fig. 4. Slightly polluted udder teats, IV points

Fig. 5. Considerably polluted udder teats, V points

Based on the results of the research and analysis of the literature data, it has been established that the process of improving the quality control of technological operations for the maintenance of a dairy herd should include the identification of the quality level and its actual assessment. Based on this, a method was developed, which is as follows: after carrying out preparatory operations of the udder for milking (washing, wiping, massage, decanting first teats of milk), the teats are treated with distilled sterile water (t = 40±2.0 °C), which is applied from the sprayer (10 treatments of 1 mL). A pre-weighed filter element (a wadded disk) is placed on the sterile free receiving vessel and placed in the treated area so that the lavage gets on the filter. The filter is then removed, dried, re-weighed and compared to the standard. The indicator is determined in points. In order to check the suitability and effectiveness of the developed method, five animals with contamination of the surface of the udder teats, which corresponded to the scores of I, II, III, IV and V points (Figs. 1-5) were selected to take the lavage and determine the group of mechanical pollution (amount of mechanical impurities on the filter) in ten repetitions - their area to the area of the filter and its mass after drying were compared to the reference sample of the filter in five repetitions. The results of checking the suitability of the developed technological approach are given in Table. 1.

Table 1. Indicators of lavage purity with different degree of contamination of cows' teats (n=10).

Contamination of teats, in % to the surface	Points	Area of mechanical impurities on the filter, in % of contamination	Mass of mechanical impurities on the filter after the drying, mg/dm^3 (per 1 L of lavage)
Not contaminated	I	absent	-
Contamination 15%	II	up to 5%	14.5±4.60
Contamination 15-30%	III	6-12%	22.5±5.30
Contamination 30-50%	IV	13-25%	51.3±10.50*
Contamination >50%	V	over 25%	89.4±13.60***

* p<0.05; **p<0.01;***p<0.001.

The analysis of the contamination of the filters, through which the lavage from the surface of the cows' udder teats was passed, shows that with the increase of the area of their contamination on the V-point scale there is an increase in the mechanical pollution of the lavages. In cows with an assessment of the cleanness of udders of II points, the area of mechanical impurities on the filter was up to 5% and their weight after drying was 14.5±4.60 mg/L, that with an assessment of III points - 6-12% of area and 22.5±5.30 mg/L, IV points - 13-25% of area and 51.3±10.50 mg/L and V points - more than 25% of area and 89.4±13.60 mg/L.

According to the mass of mechanical impurities on the filter after drying, when assessed at IV points, this indicator probably prevailed over the same value for the assessment at II points by 36.8 mg/dm^3 ($p<0.01$). In addition, when assessed at III points, the amount of impurities significantly influenced the indicator obtained for the assessment at IV points by 28.8 mg/dm^3 ($p<0.05$). In turn, the amount of impurities on the filter for the assessment in V points turned out to be significantly higher compared to the similar value for the assessment in II points ($p<0.001$). At the same time, according to the mass of impurities on the filter when evaluated at V points, this indicator was highly probable for a similar value when evaluated at IV points at 38.1 mg/dm^3 ($p<0.05$) and probable at evaluation at III points at 66.9 mg/dm^3 ($p<0.001$). The correlation coefficient between the total point estimate of the degree of contamination of the udder and the mechanical impurities on the filter after drying has a high value ($r = 0.966$). In addition, the correlation coefficient between the area of mechanical impurities on the filter and their mass after drying has the value - $r = +0.99$. At the same time, it was found that the degree of contamination of udder teats as a percentage of the area and the area of mechanical impurities on the filter (%/degree of contamination) have the highest correlation value ($r = 0.999$). Due to the need to have information and to determine the relationship between bacterial contamination levels of teats and milk, the possibility of assessing the quality of cow's milk was evaluated depending on the degree of contamination of the udder. Analysis of the results of studies of the study of contamination of lavages from cow udders according to the developed point scale and bacterial milk contamination (cows) of cows allowed to establish the average numerical values of these indicators and their compliance with the milk grade according to National Standard of Ukraine DSTU 3662:2015 (Table 2).

Table 2. The influence of the condition of the cows' udder on bacterial contamination of milk (n = 12)

Point	Contamination of the lavages from the teats, mg/L	CFU of milk, thous./cm^3
I	19.0±1.67	87.0±8.0
II	44.0±2.45***	246.0±16.0***
III	77.0±4.36	378.0±47.0
IV	119.0±7.34***	2668.0±85.0***
V	158.0±11.38***◊	3387.0±256.0***

*p<0.05; **p<0.01; ***p<0.001.

The assessment of the cleanness of the udder teats according to a 5-point scale probably influenced the degree of contamination of the lavages. Thus, the level of lavages contamination between I and II points was 2.3 times higher. When the udder teats pollution was assessed at V points, the amount of contamination in lavages compared those at I and II points increased by 8.3 and 3.6 times, respectively, at $p<0.001$ in both cases. As the assessment was reaching from III points to that of IV points, a high degree of probability of contamination of lavage from the cow's udder teats ($p<0.001$) was established, and when approaching from IV to V points, the difference in lavage contamination from the cow's udder teats was higher by 1.3 times.

In the process of statistical processing of the data on the bacterial contamination of the milk, the following picture was observed: the same probability $p<0.001$ was observed when pollutiom was assessed at I and II points, which is similar to the assessment between III and IV points. It was found that when the teats cleanness was evaluated at I point the number of microorganisms in milk was 87.0±8.0 × 10^3 per cm^3, which corresponds to the "Extra" grade. When the contamination of udder teats was assessed at II points, compared to I, the number of microorganisms in milk increased by 2.8 times - up to 246.0±16.0 × 10^3 per cm^3 at $p<0.001$. At the same time the milk met the requirements of the highest grade. In samples of milk of cows with contamination of udder teats at III points the number of microorganisms was 378.0±47.0 × 10^3 per cm^3, which is 291 × 10^3 per cm^3 CFU more than when in those estimated at I point ($p<0.001$) and this, accordingly, refers milk to the first grade. The assessment at IV points corresponded to milk with bacterial contamination of 2668.0±85.0 × 10^3 per cm^3, which is 7 times more than in that at III points ($p<0.001$). According to these data, the milk samples met the requirements of the second grade. With the assessment at V points, compared to that at IV points, milk had 1.3 times higher bacterial contamination at $p<0.05$. In addition, it was found that the correlation coefficient between the total point estimate of the degree of contamination of cow udders and mechanical contamination of lavage has the highest value ($r = 0.996$).

Table 3. Point assessment of teats cleanness according to microbial indicator

Scale	Microbial proliferation on a nutrient medium	Area of cell-culture dish with microbial proliferation, %
I – good	no growth	-
II - satisfactory	insignificant growth	< 5
III - unsatisfactory	significant growth	≥ 5

Under production conditions, the evaluation of the microorganisms content found on the udder teats surface was carried out based on the calculation of the colonies grown in the cell-culture dish (Fig. 6). A positive correlation was established between the degree of contamination of the cow udder teats according to the point assessment and the level of the bacterial contamination of milk ($r = 0.919$). There is also a high correlation between the contamination of the lavages from udder teats and bacterial contamination of milk ($r = 0.947$). In order to identify the relationship between contamination of udder teats according to the developed 5-point scale and their bacterial contamination, there is a need to develop an appropriate method. In the process of identification, along with other properties, the cultural characteristics of microorganisms - the growth characteristics of dense, liquid and semi-liquid nutrient media under certain conditions - are studied. In practice, a simple subjective method based on a visual comparison of the turbidity of the bacterial suspension under study is widely used. It is also necessary to establish the number of microbial cells per a unit of the volume of material during veterinary-sanitary evaluation when calculating the virulence of the microorganism. Based on these initial data, a method for assessing the quality of cow udder hygiene has been developed, which is as follows: after the purification of the udders of the udder (washing with the use of special means), the imprint of the udder teats is made on the nutrient medium contained in a Petri

dish. After that, according to the microbial proliferation the quality of hygiene of cow udders is assessed. The obtained indicators were determined in points. The interpretation of the obtained results was carried out using the following classification of the degree of contamination by the microbial proliferation on the nutrient medium: I point - good (no growth of microorganisms); II points - satisfactory (slight growth of microorganisms); III points is unsatisfactory (significant growth of microorganisms on the nutrient medium).

The results of the microbial proliferation in the nutrient medium in accordance with the area of the Petri dish are presented in Table 3.

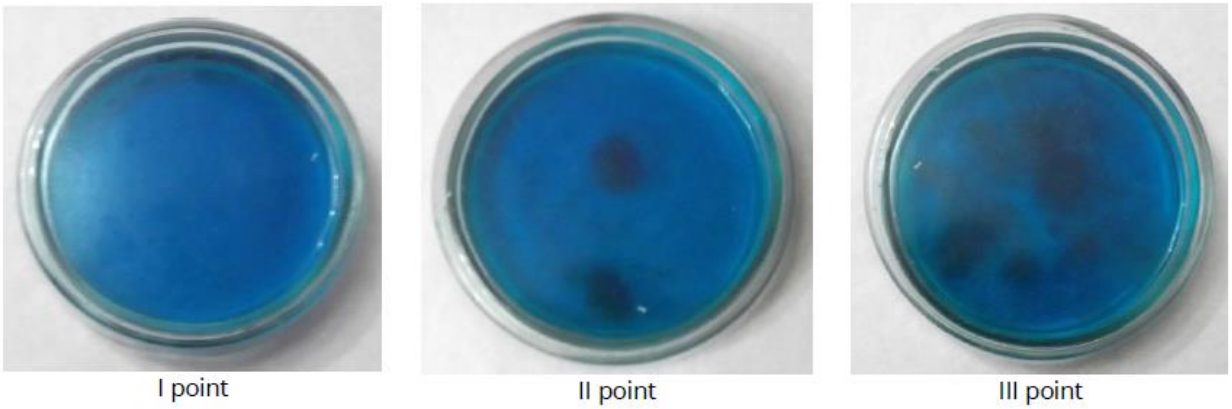

Fig. 6. Visual distribution of cows' teats cleanness according to the point scale

Thus, the correlation between the level of contamination of udders on the developed five-point scale and the degree of their bacterial contamination was revealed. The score of I point on the growth of microorganisms on the nutrient medium is attributed to the udder, whose assessment by the technological approach of determining the quality of cows' udder treatment before milking was I and II points; II points according to the bacterial test referred to III and IV points; III points according the growth of microorganisms - to those evaluated in V points. Modern milk production technology is based mainly on biological, engineering and economic knowledge. These sciences specify and determine what should be done to produce milk, and the technology that accumulates the necessary provisions of these sciences, as well as the practical experience, answers the question of what to do to obtain milk in the production process with the highest efficiency (Borshch et al., 2017; Paliy et al., 2018).

Agricultural products, such as milk, are in high demand among the population, but in the presence of a sufficiently high demand for this product, the producer, as never before, puts forward an issue of ensuring and improving its quality (Czajkowska et al., 2015). World practice proves that, regardless of the number of cows, enough milk with high technological parameters can be obtained, provided that the industry is managed in accordance with advanced technologies and taking into account the specific conditions of agricultural production in the country (Nanka et al., 2018).

Our research is relevant and consistent with some others (Fischer et al., 2015; Khaniki, 2007; Miller et al., 2015) and proved that to maintain a high level of sanitary and hygienic state of milk production it is necessary to strictly adhere to the established standards and use innovations aimed at improving the technological process of production of high-quality dairy cattle products. The current crisis phenomena in domestic dairy cattle farming have led to a decrease in production volumes and deterioration in product quality. The problem of the sanitary quality of milk has become particularly relevant right now due to the relatively high profitability of milk production (Sklyar et al., 2017). Therefore, the improving of the productivity of the dairy cattle and milk quality remains relevant.

Conclusion

Five-point system for assessing the hygiene of cow teats was developed to evaluate the ecological situation of dairy complexes, to control the level of hygiene and to set the problem areas. The dependence between the level of contamination of udder and the degree of their bacterial contamination was revealed. Positive correlation between contamination of cow's teats by scoring and bacterial milk contamination was also established, whereas high correlation was found between contamination of the lavage from teats and bacterial contamination of the milk.

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