Hygiene products for udder health of lactating cows

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Abstract

The introduction of the “Milking Protocol” on the farm is a mandatory condition for preventing intramammary infections, maintaining cows’ productivity, and improving milk quality. Treating udders with hygiene products is an effective preventive udder care measure in most dairy herds. The choice of an antiseptic agent for udder health should be based on its proven effectiveness, which is necessary to register the drug as a veterinary medicinal product. The purpose of the study was to get acquainted with the current literature on the use of hygiene products for the health of the udder of lactating cows. While writing this review article, we got acquainted with the results of modern scientific research, conducted their analysis and theoretical justification, and summarized the data obtained on using hygienic means for sanitizing the udder of lactating cows. For this purpose, the Polissia National University scientific library funds, scientific search systems Science-Direct, and PubMed were used. This means that sanitation of the mammary gland should have an antiseptic effect and keep the breasts in good condition. Declared composition of registered drugs in Ukraine: iodine, chlorhexidine, organic acids. Hygienic products include cosmetic surfactants that soften the skin and form a moisturizing hydrophilic layer on the skin. Means for udder hygiene, as a rule, are products of chemical origin, and using these drugs creates a risk of chemical elements entering the milk. An alternative to these potential dangers can be probiotic-based products that are environmentally friendly and harmless to the animal body. In the conditions of war and economic troubles, the specialists of the dairy industry are offered preparations of plant origin for the disinfection of cow udders, where medicinal plants are used as raw materials, from which infusions, decoctions, water extracts, alcohol- and oil-based solutions are prepared. Applying dipping procedures is an integral part of the preventive measures of the anti-mastitis program. The choice of means for disinfecting udders after milking must be made depending on the circulation of pathogens in the herd and consider all factors in the conditions of a specific product. In this regard, I believe that a promising direction of scientific research is the use of nanotechnology in the development of new antiseptics, the study of their effect on the health of the udder of lactating cows, the use of probiotics as a dip, as an alternative to substances of chemical origin.

Keywords: hygiene products; udder health; udder disinfection; lactating cows; mastitis; dipping; bacterial load.

1. Introduction

Dairy farming is one of the main components of the economy concerning the production of food products of animal origin. Nowadays, the dairy industry of Ukraine is suffering because of the war and keeping cattle on a large territory under challenging military operations; it is increasingly important to provide an opportunity to guarantee the production of high-quality and valuable food products. The socio-economic development of the state as a whole depends on the situation in milk production.

Following the obligations under the Association Agreement with the European Union, Ukraine harmonized its legislation with the provisions of Regulation (EU) No. 853/2004 on special rules for the hygiene of food products, including raw milk. As a raw material, its quality is regulated by the national regulatory document SSTC 3662:2018, “Raw milk of cows. Specifications”.

Low content of somatic cells, insignificant bacterial in-semination, and the absence of human pathogenic microorganisms and toxic substances characterize high-quality raw milk (Barkema et al., 2015; Ndahetue et al., 2019). The udder health of lactating cows plays an important role (Breen, 2019). World experience and domestic practice testify that the introduction of the “Milking Protocol” in the farm, compliance with a precise sequence of actions is a mandatory condition for preventing mammary gland diseases (Sokoluk et al., 2022). Special attention is paid to the methods of udder hygiene, which consists of treating udders with detergent solutions before milking (pre-dipping) and preserving the teat canal with film-forming agents (dipping). This is part of the Comprehensive Plan of Mastitis Control in cows (Geary et al., 2013). Commercial structures and industry respond to the requests of dairy farming specialists with a wide range of different means for udder care (dipping) (http://www.milkfarm.com.ua). Due to the offer on the market of a large number of udder hygiene products, in-
structions for their use, recommendations and reviews of practitioners, scientific publications, the presence of numerous literature on the study of the effect of disinfectants for sanitizing the skin of lactating cows on the animal body, a significant number of questions remain unsolved (Muzyka et al., 2021). The question of the choice and use of disinfectants, circulation control, use on dairy farms, harmlessness for animals, and obtaining high-quality and safe milk becomes relevant.

Therefore, the research aimed to get acquainted with current literature data on using hygienic means for the health of the udder of lactating cows.

2. Materials and methods

While writing this review article, we got acquainted with the results of modern scientific research, conducted their analysis and theoretical justification, and summarized the data obtained on using hygienic means for sanitizing the udder of lactating cows. For this purpose, the Polissia National University scientific library funds, scientific search systems Science-Direct, and PubMed were used.

3. Results and discussion

In their research, Belage E. et al. (2017) studied which cow milking management methods have the most significant impact on udder health. A national survey described the current extent of adoption of milking practices on Canadian dairy farms and identified factors associated with their use. After surveying 1,373 milk producers, scientists concluded that, in general, Canadian farmers follow recommendations for milking procedures. Cleaning of udders before and after milking, using disposable towels for each cow, and treating udders with a disinfectant after milking was widespread. At the same time, the use of gloves by milkers and treating udders with disinfectants before milking is practiced less. Adoption rates for several dairy farm practices were significantly related to the milking system, herd size, and country region.

The simultaneous effect of udder health management practices on the number of somatic cells in milk was studied by S. Dufour et al. (2011). Based on the scientific literature analysis and their research data, the authors concluded that most practices with constant associations with the number of somatic cells were related to milking procedures. An essential condition is gloves during milking, using means for treating udders, and milking problem cows last. It is necessary to conduct an annual inspection of the milking system and use equipment that ensures the standing position of the cows after milking. All these practices were consistently associated with a decrease in the number of somatic cells in milk.

The research by Z. Deng et al. (2019) indicates multiple risk factors for mastitis in cows on a farm with automated and conventional milking systems, particularly concerning udder hygiene products. However, udder health requires more attention on larger complexes with automated milking systems than smaller farms.

T. Lam et al. (1995) believe that disinfection of udders after milking is effective against pathogens Staphylococcus aureus and Streptococcus agalactiae and is an essential part of standard preventive measures against mastitis in dairy cattle. However, there are discussions due to the effective-
environment (Hutchison et al., 2005). At the same time, disinfection of udders after milking reduces the cases of mastitis in cows (Comprehensive Plan of Mastitis Control). One of the six essential points is proper milking hygiene and treating udders with disinfectants before and after. Pre-milking disinfection of udders (pre-dipping) is to clean dirt, remove preservative residues before milking and destroy microorganisms, which reduces their colonization on the skin and contamination of the mammary gland. Means for treating the udder before milking contain detergent and disinfectant components of various types and are divided into ready-made and concentrated (Schukken et al., 2003). The following preparation stage for milking cows is drying and wiping the udders with disposable or reusable napkins. High-quality napkins have a water-resistant hydrophilic structure, which almost completely removes dirt and moisture from the surface of the udders, thereby preventing their injury during milking. It is a mandatory condition (Miseikienė et al., 2015) that the processing and udder of each subsequent animal must be carried out with a fresh napkin. After disinfection of teats (dipping), the milk duct is closed from the penetration of harmful microflora into the internal space of the udder. It should also be noted (Ibrahim et al., 2015) that the skin of cows after milking can serve as a place for the entry and development of pathogenic microflora. Manufacturers offer hygienic products with various active substances and concentrations based on iodine, chlorhexidine, and organic acids (lactic, peracetic, formic, etc.).

The choice of means for disinfecting udders after milking must be made depending on the circulation of pathogens in the herd. High requirements are placed on the preparations for dipping: reliable protection of the milk duct from the penetration of pathogenic microflora, a beneficial effect on the skin, no irritation, a stable and prolonged effect, quick drying, and complete removal before the next milking. In addition, such products should exhibit cosmetic properties, improve the condition of the skin of cows, and have a pleasant smell.

Naqvi S. V. et al. (2018) emphasize that when creating preparations for dipping procedures, which include several ingredients from different classes of chemical compounds, they should complement each other, be safe for human and animal health and not pollute the environment. Means should have a broad spectrum of antiseptic action against microorganisms and fungi, be characterized by a short latent period, high activity, and exhibit a preservative effect.

Other authors (Bohm et al., 2017) believe that the main requirement for disinfectants is the absence of an irritating effect on the skin of cows, minimal absorption from the site of their application, absence of allergic effects, and low toxicity. After milking, hygiene products for cow udder health are usually based on iodine, chlorhexidine, and lactic acid salts. One of the critical properties of complex preparations for udder hygiene is the preservation of the milk duct and prolongation of the bactericidal effect until the next milking. Film-forming liquids are conventionally classified according to the thickness of the film formed on the skin. When a thick film is formed, the sphincter of the milk is mechanically closed, and the consumption of the product is, on average, 9–11 ml per treatment of one cow, which is not economically profitable. The applied drug dries for a long time, from 20 to 120 minutes, and some do not dry. Litter, grass, and straw stick to the ponds; we get additional pollution risks instead of the desired hygiene. A thick film can cause a greenhouse effect and maceration (softening, wetting, and swelling) of the skin. Medium-film products are called “second skin”, as they form a reliable breathable film and mechanically close the teat sphincter. On average, 5–6 ml of the product treats one cow, drying quickly (in about 7–20 minutes).

It should be noted that if the drying time of the drug is more than 15 minutes, there is a risk of losing the integrity of the film if the animal lies down immediately after milking. Thin-film products form a thin protective layer on the surface of the milk and are characterized by a small consumption (3–6 ml per treatment of one cow). At the same time, there are risks regarding their damage; thus, they do not provide any protection and hygiene of the udder.

According to the State Research Institute of Veterinary Medicines and Feed Additives (Lviv) data, 17 preparations for treating udder teats are currently registered in Ukraine (table No. 1, https://www.scivp.lviv.ua).

The above drugs' main components are iodine, chlorhexidine, and organic acids. Usually, to increase the drug's effectiveness, other ingredients are added to its composition. Udder care products may contain a single drug or a combination (Naqvi et al., 2018). The table shows drugs that often have different brands, but there are analogs regarding active substances.

It should be noted that the range of cow udder hygiene products available in Ukraine is much more extensive. The relevant bodies of the executive power, which control this process, must promptly respond to these challenges. For example, Ireland (an EU country) uses 96 commercially available means for disinfecting the skin of udders. Before a heat treatment can be used commercially, it must be registered with the Department of Agriculture, Food and the Marine (DAFM), the Health Products Regulatory Authority (HPRA), and comply with European legislation. According to HPRA requirements, without medical claims, a disinfectant intended for application to the skin for hygienic treatment may be classified as a biocide and not a veterinary medicinal product (HPRA, 2019). It is subject to registration following the Regulation on biocidal products (EU Regulation No. 528 of 2012). Within the European Union, its member states must use a common standard to evaluate the means used to disinfect the udder. This European Standard (EN), or BSEN 1656, can be used to compare a range of udder health products (Lopez-Banevides et al., 2012; Garvey et al., 2017; Fitzpatrick et al., 2019). In Ireland, the causative agents of mastitis among cows are mainly Staphylococcus aureus, Streptococcus uberis, Escherichia coli (Keane et al., 2013). Treatment of udders with antiseptic agents reduces the level of infection by pathogens. It reduces the bacterial load on the surface of the udder skin, which is the main component of modern milking technology (Vijaya Kumar et al., 2012).
Table 1
Preparations for sanitary processing of the udder, registered in Ukraine

<table>
<thead>
<tr>
<th>№</th>
<th>Name of the drug (manufacturer, country)</th>
<th>Declared composition of the drug</th>
<th>The use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Masodine</td>
<td>100 ml of the drug contain the active substance, wt.%: iodine – 2.15</td>
<td>For disinfection of teats after milking</td>
</tr>
<tr>
<td>2</td>
<td>Masofil</td>
<td>100 g of the drug contains the active substance: iodine – 0.25 g</td>
<td>For disinfection of teats after milking</td>
</tr>
<tr>
<td>3</td>
<td>Pre-Dip</td>
<td>100 g of the drug contains the active substance: iodine – 0.1 g</td>
<td>For disinfection of teats before milking</td>
</tr>
<tr>
<td>4</td>
<td>Synodex</td>
<td>100 ml of the drug contain the active substance: %: lactic acid – 5.6</td>
<td>For disinfection of teats before and after milking</td>
</tr>
<tr>
<td>5</td>
<td>Quat Chem Ltd, Great Britain</td>
<td>100 ml of the drug contain active substances, %: lactic acid – 1.6; iodine – 0.3.</td>
<td>For disinfection of teats before and after milking</td>
</tr>
<tr>
<td>6</td>
<td>Coke Ltd</td>
<td>1 g of the drug contains the active substance: chlorhexidine digluconate – 5.0 mg</td>
<td>For disinfection of teats after milking</td>
</tr>
<tr>
<td>7</td>
<td>CID Lines NV/CA, Belgium</td>
<td>1 g of the drug contains the active substance: iodine – 3 mg</td>
<td>For disinfection of teats after milking</td>
</tr>
<tr>
<td>8</td>
<td>Kenolac</td>
<td>100 g of the drug contain active substance (%): lactic acid – 3.6</td>
<td>For disinfection of teats before milking</td>
</tr>
<tr>
<td>9</td>
<td>CID Lines NV/CA, Belgium</td>
<td>100 ml of the drug contain the active substance: %: lactic acid – 8.0.</td>
<td>For disinfection of teats before milking</td>
</tr>
<tr>
<td>10</td>
<td>Keno Pure</td>
<td>100 ml of the product contains the active substance, %: iodine – 0.55</td>
<td>For disinfection of teats before and after milking</td>
</tr>
<tr>
<td>11</td>
<td>Ypred Sass, France</td>
<td>100 ml of the product contains the active substance, %: lactic acid – 2.0; salicylic acid – 0.099</td>
<td>For disinfection of teats before milking</td>
</tr>
<tr>
<td>12</td>
<td>Prefoam plus</td>
<td>100 g of the drug contain the active substance (g) lactic acid 8.0</td>
<td>For disinfection of teats after milking</td>
</tr>
<tr>
<td>13</td>
<td>Filmadin</td>
<td>100 g of the drug contain the active substance: iodine – 0.5 g</td>
<td>For disinfection of teats after milking</td>
</tr>
<tr>
<td>14</td>
<td>Ypred Sass, France</td>
<td>The drug contains the active substance: iodine – 0.25 %</td>
<td>For disinfection of teats after milking</td>
</tr>
<tr>
<td>15</td>
<td>Dijalavil NV, Belgium</td>
<td>100 ml of the drug contain the active substance: iodine – 0.15 %</td>
<td>For disinfection of teats after milking</td>
</tr>
<tr>
<td>16</td>
<td>Dipal Cone</td>
<td>100 ml of the drug contain the active substance: iodine – 0.75 %</td>
<td>For disinfection of teats after milking</td>
</tr>
</tbody>
</table>

K. Wattenburger et al. (2020) studied the effect of four different methods of disinfection of teats on their contamination by microorganisms before taking milk samples from lactating cows. Treatment methods used before milk sampling included: 1 – no preparation; 2 – pre-milking disinfection and one-time wiping of teats with a towel; 3 – processing of the milk only with alcohol; 4 – disinfection before milking after a single wipe with a towel and treatment of the udders with alcohol. After taking milk samples from 168 cows, including 665 udder quarters, 1,614 isolates of microorganisms were sown and obtained. The first and second groups of cows had more contaminated milk samples than the third and fourth, while the third group had more microorganism contamination than the fourth. Most isolates of Pseudomonas spp. were identified in milk from the second group of cows. Thus, treatment of udders with alcohol, after preliminary disinfection before milking with an iodine-based agent and their drying, minimizes the contamination of milk by microorganisms during sampling.

There are many reports on iodine-based udder treatments (Enger et al., 2015; Martins et al., 2017). However, using preparations containing iodine can lead to high concentrations of this element in milk, which may be of particular concern to manufacturers of dairy baby food products (O’Brien et al., 2013). In Ireland, commercially available teat disinfectants contain iodine, chlorhexidine, chlorine dioxide, lactic and salicylic acids, or various combinations of these ingredients.

Based on the research conducted (Lago et al., 2016), it was proved that iodine is an effective means of disinfecting milk cows against staphylococci. As expected, the concentration of the product’s active substances does not always lead to a decrease in the highest level of the number of bacteria. At the same time, when using and/or different concentrations of ingredients, levels and strengths of additional ingredients, such as emollients, can affect the effectiveness of disinfection while making the skin more elastic.

The research carried out by Sliwinski B. et al. (2015) indicates that hygienic treatment of udders with means where iodine was used as a disinfectant additionally increases the content of this element in milk by approximately 15 μg/l, i.e., 35 % more than from cows of the control group.

Martins C. M. et al. (2017) investigated the effectiveness of a barrier disinfectant for udders with a high free iodine content to prevent new intramammary infections and clinical mastitis in lactating cows. In the control group of cows, a conventional agent without barrier properties and a low free iodine content was used as a disinfectant. It was established that the most common microorganisms in cow’s milk were Streptococcus spp. (6.2 %) of the total milk quarters, followed by coagulase-negative staphylococci (3.6 %) and Corynebacterium spp. (1.5 %). Treatment of the skin of cows after milking with a product with barrier properties and a higher iodine content reduced the risk of clinical mastitis in cows by 46 %.
The influence of some factors on the high content of iodine in milk was studied by G. Flachowsky et al. (2013). It was established that an essential source of this element is its content in the feed, although the treatment of udders with iodine-containing means also affects its level in milk. Therefore, with the aim of preventive consumer protection, the European Food Safety Agency proposed to limit the iodine content for lactating cows from 5 to 2 mg/kg of dry matter of feed.

Iodine-based disinfectants have a broad spectrum of antimicrobial action, do not cause the habituation of pathogenic microflora, and have an anti-inflammatory effect. At the same time, it is rather challenging to combine with udder care products, emollients, moisturizers, and repellents, as it is very reactogenic. There is also a danger of individual sensitivity to iodine-based preparations, with impaired kidney function, hypothyroidism, and thyroid disorders. It should be borne in mind that, with frequent use, iodine solutions can cause hyperkeratosis of the skin of the breasts. PVP-iodine is used in udder hygiene products, where the active substance is bound into a polymer complex. Iodine is slowly released and retains high antiseptic properties during an extended stay on the skin. PVP-iodine solutions are not toxic for long-term and frequent use, rarely cause allergic reactions, and are stable during storage (Baumberger et al., 2016).

The purpose of research by S. N. Godden et al. (2016) was to demonstrate the lack of superiority of a previously tested control iodine-based post-milking cow disinfectant compared to a new formulation containing glycolic acid. Three hundred lactating cows were involved in the experiment, which lasted twelve weeks. After milking, the udders of two groups of animals were treated by immersing them in dipping cups with an experimental product (EC) and positive control (PC). The incidence of new infections partially differed between quarters of udders treated with EKS (3.9 %) compared to those treated with PC (4.2 %). Similarly, the prevalence of infection was generally low among quarters treated with ECS (3.92 %) compared to PC (5.03 %). There was no significant difference when evaluating the number of somatic cells in milk from cows of both groups. Therefore, the means for treating udders based on glycolic acid after milking is effective and safe, as it does not irritate the skin and positively affects its condition.

Quirk T. et al. (Quirk et al., 2012) investigated the effectiveness of treating udders with iodine-containing preparations after milking concerning coagulase-negative staphylococci colonization of the milk duct and the frequency of intramammary infections. For the study, a split udder model was used for forty-three lactating cows of the Holstein breed. It was established that most IMls in cows were caused by Staphylococcus chromogens (30 %) and Streptococcus xylosus (40 %). A noticeable decrease in the number of microorganisms on the skin of the udders after treatment was noted. It should also be noted that the effect of disinfection of udders on IMI was not the same for all coagulase-negative Staphylococci. According to the authors, this affects the selection of hygiene products for udder health on each dairy farm.

The research by R. I. Anggraini et al. (2020) indicates the high effectiveness of antiseptic iodine-containing products. At the same time, these drugs have their advantages and disadvantages. Every three months after using a hygienic product on the farm, it is necessary to rotate it due to the habituation of microorganisms and the formation of stable resistant forms in the dairy herd.

Other authors (Leslie et al., 2006) tested a 1 % iodoform udder disinfectant (Full-Bac) versus a control (Bobadin) against Staphylococcus aureus and Streptococcus agalactiae in an experiment. Studies were conducted on 41 lactating cows for ten weeks following the recommendations of the National Mastitis Council. The scientists found no significant difference between the study drug and the control in the occurrence of new intramammary infections due to Staphylococcus aureus, which averaged 13.4 % in each group. There was no difference in new occurrences of mastitis caused by Streptococcus agalactiae, which averaged 8.5 % and 6.1 % for both groups. The tested disinfectant for the treatment of udders showed similar bactericidal activity compared to the control, without harming the skin and condition of the udders in the warm period of the year.

The research by A. Whist et al. (2007) was to study the reduction of Staphylococcus aureus and Streptococcus agalactiae among lactating cows with the use of dry therapy and treatment of udders after milking. Iodine-based products (experimental group) and Dray Fextra (control group) sealant for udders were used for two years. In milk samples from experimental cows, the level of Streptococcus agalactiae insinuation increased from 14.2 % to 15.2 %. At the same time, from animals in the control group, the level of Staphylococcus aureus insinuation in milk decreased from 65.9 % to 54.9 % two years after the beginning of the research.

There are antiseptics with various active substances on the world market of veterinary drugs. Thus, disinfectants based on chlorhexidine provide an instant bactericidal effect; simultaneously, it has a somewhat narrower spectrum of action than iodine. After some time, with the constant use of chlorhexidine, the pathogenic microflora becomes accustomed to it, which requires periodic replacement no more than three months later. At the end of clinical studies, it was established that chlorhexidine with a concentration of 0.5 %, or 5000 ppm, had a versatile effect. It is known that the bactericidal effect of chlorhexidine is manifested in a concentration of more than 0.01 % (100 ppm.) already after 1 minute at a temperature of 22 °C against 99 % of gram-positive and gram-negative bacteria. Absorption of chlorhexidine with intact skin is negligible and is no more than 5 %. However, its absorption can increase 100 times in case of skin damage. That is, the higher the concentration of chlorhexidine in the product, the greater the probability of its entering the blood.

The authors also studied the efficacy of a 0.35 % chlorhexidine milk treatment containing glycerin as an emollient to prevent IMI in cows. Streptococcus agalactiae was not detected in the dairy herd before the study, and the percentage of Staphylococcus aureus was relatively low. New cases of infection with Streptococcus uberis and Streptococcus agalactiae species occurred much less frequently in the udders of cows treated with chlorhexidine. The overall efficiency of using means for disinfecting udders against the main causative agents of mastitis was 50 %. A reduction of coagulase-negative staphylococci by 49 % and Sorinobacterium bovis by 65.2 % was noted. During the test, the disinfectant showed a moisturizing and softening effect and did not cause side effects; that is, it had a positive effect on the health of the udders of lactating cows.
In his research, Boddie R. L. et al. (2000) found that a teat disinfectant containing only chlorhexidine achieved one of the highest log reductions (82.5 %) against staphylococcal isolates on the skin of teats. It was proved (Bohm et al., 2017) that the drug with chlorhexidine reduces the number of staphylococci on the skin of udders by 4.46 times, compared to washing and drying the udder.

Research conducted by Oliver S. P. et al. (1993) indicated that treatment of udders after milking with a preparation containing perchloric acid and chlorine dioxide in a soluble polymer gel was effective in preventing new intramammary infections and against a variety of mastitis pathogens. According to R. F. Sheldrake et al. (Sheldrake & Hoare, 1980), the disinfection of udders before milking using a 2 % chlorhexidine solution in a detergent base did not reduce the frequency of new cases of intramammary infections caused by Staphylococcus aureus in lactating cows. At the same time, treatment of udders after milking with a preparation containing 5000 mg/l of free iodine significantly reduced the staphyloccocal population of the udder skin and the incidence of mastitis in cows.

The purpose of research by S. R. Fitzpatrick et al. (2019) is to compare the reduction of bacterial populations on the skin of udders after using different commercial udder disinfectants. Ten different udder treatments were applied to each cow. Before the application of the disinfectant, staphylococcal isolates were the most common bacterial group detected on milk smears (49 %), followed by streptococcal (36 %) and coliform (15 %) species of microorganisms. The average reduction of these bacteria on the skin of the udders was 76 %, 73 and 60 %, respectively. All tested udder disinfectants reduced bacterial udder load for all groups of microorganisms. The agent with the active ingredient 0.6 % diamine solution was the most effective against bacterial populations of staphylococcal and streptococcal isolates on the cows’ skin, with a 90 % and 94 % reduction, respectively. Applying a 0.5 % iodine solution resulted in a 91 % coliform reduction. Research results show that specific bacterial loads on teats can be reduced by using different ingredients in disinfectants.

Research by Mondin A. et al. (2014) proved that diamine is the most effective against staphylococcal isolates. In addition, this preparation was previously tested using the disk diffusion method, resulting in some of the lowest inhibition zones for Staphylococcus aureus. Diamine is known to be stable over a wide pH range and effective in the presence of heavy organic contamination of the cow’s skin. This explains why this ingredient is less affected by the organic substances on the cow’s skin than other ingredients.

Previous studies (Miseikirme et al., 2015) showed the effectiveness of lactic acid against streptococcal bacteria. A foaming solution containing only lactic acid reduces the number of Streptococcus uberis colonies on the skin of cows by 3.5 times. In addition, treatment of udders with a 2 % lactic acid solution combined with a 0.1 % salicylic acid solution achieved a 63 % reduction in CFU/ml against streptococcal isolates naturally present on the skin of the udders. A study was conducted by J. E. Hillerton et al. (2007) on the efficacy in preventing new intramammary infections of a teat dip containing acidified sodium chloride Udder Gold Platinum Germicidal Barrier Teat Dip (UGPt) compared with the licensed iodofome teat disinfectant Iosan Novartis Animal Health (INAH). In addition, they studied how the drugs affected the condition of the skin of the cows. At the end of the experiment, it was established that the number of clinical cases of mastitis was the same in each group of cows (n = 13), and the manifestation of subclinical infection was slightly lower in the UGPt group than in the INAH group (27 vs. 31, respectively). The obtained results indicate that both agents do not differ in their ability to prevent the new occurrence of IMI and positively affect the condition of udders.

The effect of a multi-ingredient post-milking udder disinfectant on skin condition, bacterial colonization, and udder health was studied by M. D. Rasmussen and H. D. Larsen (Rasmussen & Larsen, 1998). Spray for treatment of udders after milking with 10 % glycerin improved skin condition (P < 0.1), compared to no treatment. A product with a chlorine dioxide content of 120 ppm. Did not affect the condition of the skin of the girls. At the same time, these components did not affect the number of bacteria on the skin of cows after infection with Staphylococcus aureus and Streptococcus uberis. However, the half-life of Staphylococcus aureus on untreated milk was the most extended (P < 0.5). According to the authors, the condition of healthy skin of cows (scores 1-4) does not affect the colonization of bacteria in the absence of cracks and ulcers (scores 5-6).

C. Vissio et al. (2020) studied the efficacy of ZkinCu, a copper-zinc-containing udder disinfectant, to prevent natural udder infections in robotic milking cows. As a control, the drug Ocean Blu was used, the active substance of which is glycicolic acid. After conducting tests, it was established that the practical means for udders ZkinCu could be more practical for preventing intramammary infections.

S. P. Oliver et al. reported the effectiveness of a disinfectant for milking cows containing a combination of phenols (Oliver et al., 2001). Disinfection of udders with this agent, combined with proper preparation of udders and their treatment after milking, reduces new intramammary infections caused by numerous mastitis pathogens during lactation.

A. M. Shevchenko et al. (2020) found that complex preparations of Forticept for cow udder hygiene have a high preventive efficiency (96 %) for the subclinical form of mastitis. The use of the means has a beneficial effect on the physiological state of the mammary gland; in particular, it reduces the number of manifestations of hyperkeratosis of the udders by 25 % and prevents the appearance of new cases the disease. At the same time, dipping procedures positively affect milk's physicochemical and microbiological characteristics, significantly improving its quality and nutritional value. Yu. V. Zhuk et al. (2017) studied the effectiveness of treating cow’s udders with Forticept Udder Forte compared to preparations where the active substances were chlorhexidine and iodine. Using the drug, Forticept reduced the incidence of cows with subclinical mastitis by 30–40 %. The product had a cosmetic effect; the dugs’ skin became softer and more elastic. In two research groups where chlorhexidine and iodine-based preparations were used as hygiene products, the incidence of subclinical mastitis decreased by 20.1 % and 13.0 %, respectively.

Research conducted by O. R. Paladiychuk (2019) indicates that freezing pre-dips and dips predictably reduces the occurrence of mastitis among cow herds by 35–45 %. Pre-milking treatment of the skin of the heifers was carried out with a 1 % solution of Kenopur strong (Belgium), which includes lactic acid, non-iodized sulfactants, and glycerin. To preserve the udder of cows after milking, Senso Dip 5
The trial was conducted on five dairy herds in Australia. During the research, weather conditions were considered, and its effect on the occurrence of new udder infections. The effectiveness of a new disinfectant for dairy cows based on probiotic bacteria was studied by Yu J. et al. (2017) on changes in the number of somatic cells in milk and profiling of bacterial microflora. For this purpose, single-molecule real-time sequencing technology (SMRT) of bacteria was used, using the treatment of the skin of cows with the preparation of probiotic lactic acid bacteria (LAB) and commercial disinfectants (CD). The number of somatic cells in the milk gradually decreased from the beginning of the use of the drugs. Still, their number (LAB) was slightly lower in the cows where probiotics were used than in the group where commercial disinfectants were used. Sequencing results indicate that milk obtained from cows in both groups contained a quantitative and specific microbial population that changed during the study.

Therefore, the obtained data indicate that the agent based on probiotic bacteria reduces the number of microorganisms that cause mastitis and eases the microbial load on the udder skin. This can be an alternative to using chemical disinfectants before and after milking for udder health. Pacific Biosciences SMRT full-length 16S ribosomal RNA sequencing has also been shown to be an essential component in monitoring changes in bacterial populations while using udder hygiene products.

Data obtained by Alawneh J. I. et al. (2020) confirm the effectiveness of lactobacilli-based products used to treat udders after milking. The latter was compared with commercial disinfectants for udders based on iodine. The effect of both types of udder treatments on the number of somatic cells in milk was evaluated using a multivariate linear regression model. A tendency was noted to decrease the number of somatic cells in milk was evaluated using a multivariate linear regression model. When testing antiseptic agents for udder health, the sanitary condition of the skin of the udders is monitored. Usually, it is performed according to the indicator of total microbial contamination of the udder skin. Research is carried out in laboratory conditions, no later than three hours after taking washings, which are taken from the skin of cows on an area of 10 cm² using sterile swabs soaked in saline in test tubes. After carefully squeezing the tampon against the wall of the test tube, make successive dilutions with distilled water 1:10, 1:100, 1:1000, and 1:10000. From the last three dilu-
tions, 1 cm² is sown on meat-peptone agar in bacteriological cups and placed in a thermostat at a temperature of 37 °C for 24–48 hours. Only cups with no continuous growth and at least ten colonies have grown are considered. The degree of dilution is taken into account, and the average number of bacteria in 1 cm² of washing, which is 1 cm² of the skin of the cows, is deduced.

Gleeson D. et al. (2009) conducted a study on two dairy farms in Ireland regarding the effectiveness of the pre-milking treatment of udders. This practice was effective against the environmental bacteria Escherichia coli and Streptococcus uberis. It was also established that the effectiveness of the disinfectant for dairy cows varies depending on the milk production technology, the year's season, and the specific causative agent of mastitis that progresses in the dairy herd.

According to G. Keefe et al. (2012), the main route of the spread of Staphylococcus aureus and Streptococcus agalactiae is cow-to-cow infection. Prevention should focus on biosecurity within and between herds to reduce or eliminate the reservoir of infection. Since the milking time is the main period for acquiring new intramammary infections, it is the focus of most preventive measures. A key factor is the disinfection of the skin of the milking cows before and after milking the cows. It has also been proven that using gloves during milking is integral to fighting infectious mastitis and obtaining high-quality milk. Prioritizing the “closed herd” principle, or at least following well-defined biosecurity protocols, is critical to reducing the risk of disease in cows.

The authors (MacKey & Miller, 2003) claim that preparations containing aloe and allantoin have a therapeutic effect on the healing of wounds and cracks on the udders, thereby improving the health of cows’ udders.

In the conditions of war and economic troubles, specialists from the “Uman Labs” laboratory offer herbal preparations for the disinfection of udders (http://umanlabs.org/uk). Medicinal plants are used as raw materials for preparing infusions, decoctions, water extracts, and aqueous solutions of dry or liquid extracts-concentrates; they are also suggested to be used on an alcohol and oil basis. Means for processing the udder are used depending on the properties of the active substance, given that their effect is somewhat weaker compared to chemotherapeutic drugs. Extracts and decoctions of thyme, eucalyptus leaves, plantain, sage, St. John's wort, calendula flowers, pine buds, and galangal rhizomes have an antimicrobial effect. The advantage of herbal preparations is their physiological nature, presence of natural components (vitamins, carbohydrates, macro- and microelements, enzymes), stimulating effect, long-term effectiveness and safety, availability, and economic attractiveness. The laboratory conducts studies of the effectiveness and safety of medicinal forms of hygiene products of plant origin concerning field strains of microorganisms that cause mastitis. The proposed solutions are relevant for cow udder health in wartime and may also be attractive in everyday life among milk producers.

Thus, compliance with a set of rules during milking allows to obtain high-quality milk and minimize the microbial load on the mammary gland. The use of disinfectants for processing the skin of udders is an essential factor in preventing mastitis. In this regard, the relevance of using hygienic means to preserve the health of the udder of lactating cows is increasing.

4. Conclusions

1. The dairy farm management system certifies that the introduction of the “Milking Protocol” in the farm, compliance with a precise sequence of actions, is a mandatory condition for preventing intramammary infections, maintaining the productivity of cows, and improving the quality of milk.

2. Treatment of udders with hygiene products is an effective preventive measure for the care of the mammary gland among most dairy cattle herds. The choice of an antiseptic agent for udder health should be based on its proven effectiveness, which is necessary to register the drug as a veterinary medicinal product.

3. According to the requirements of the European Union, before the preparation for treating the udder can be used for commercial purposes, it must be registered according to the current legislation. Within the EU, its member states must use a common standard to evaluate the means used to disinfect the udder.

4. Means for sanitation of the mammary gland should have an antiseptic effect and maintain the breasts in good condition. Declared composition of registered drugs in Ukraine: iodine, chlorhexidine, organic acids. Hygienic products include cosmetic surfactants that soften the skin and form a moisturizing hydrophilic layer on the skin.

5. Means for the hygiene of the udder, as a rule, are products of chemical origin, and when using these drugs, there is a possible risk of chemical elements entering the milk. An alternative to these potential dangers can be probiotic-based products that are environmentally friendly and harmless to the animal body. In the conditions of war and economic troubles, animal husbandry specialists are offered preparations of plant origin to disinfect the cows’ udders, where medicinal plants are used as raw materials, from which infusions, decoctions, water extracts, alcohol- or oil-based solutions are prepared. Maintaining the health of the udders of lactating cows is an essential task of the veterinary service of milk production farms. Applying dipping procedures is an integral part of the preventive measures of the anti-mastitis program. The choice of means for disinfecting udders after milking must be made depending on the circulation of pathogens in the herd and consider all factors in the conditions of specific products.

Conflict of interest

The author declare that there is no conflict of interest.

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