TECHNOLOGICAL INTEGRATION BY INVENTION OF NEW QUALITATIVE MEANS FOR FOOD INDUSTRY

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Integration changes of modernity envisage merging, uniting, becoming of new links and restoring the once broken between separate sections of not only economic, social, cultural and even linguistic processes. Attracting and implementation of energy efficiency and environmental processes is a major task of high technology. That is why technological integration is one of the most pressing challenges of our time. For effective implementation in the "European technological space" precisely technological integration is the basic task that has been set before the agricultural, industrial and economic sectors of Ukraine. Attracting of new modern technological processes in various production fields is a prerequisite for the formatting of Ukraine as a state with a powerful sector of production of competitive products. Undoubtedly, the main emphasis is on the food industry sector.

Modern requirements for domestic production and its successful promotion to the world market require compliance with quality standards. There are special requirements for the food industry, including dairy products. The main task facing the Ukrainian producers is to ensure high taste properties and safety for consumers with optimal pricing policy. As stated in [1] “safety is the absence of harmful chemical and biological impurities, including pathogenic microorganisms and poisonous substances. Microbiological stability is the potential for storage of products without deterioration”.

That is why special attention is paid to modern technologies of processing and production of dairy products. So application of the principle of circulating CIP cleaning has become the main trend in the effective and economical solution to the problem of washing and disinfection of technological equipment [1].

Due to inaccessibility of internal surfaces their washing and disinfection are the biggest problems. Really developers offer a lot of detergents. A detailed analysis of the modern market of alkaline detergents is presented in [2].

Mixtures for washing produced in France, Estonia, Sweden and Germany have excellent detergency, but the high price, that significantly increases the cost of raw materials.

The alkaline mixture «CircoSuper AF» and «CircoSuper AFM» should be used only in soft water and water of medium hardness.

Due to commercial confidentiality the manufacturers do not represent the concentration content of components of mixtures. Therefore, known patented detergents were taken by the authors as control means.

For example, a known alkaline detergent is used in a CIP sink for preliminary processing of process equipment [3]. It relates to the production of technical detergents and cleaning agents for the processing of equipment of food industry enterprises. This composition contains (% by weight) an optimized mixture of alkyl glucoside and ethoxylated alcohols (1.0 – 3.0), sodium hydroxide (3.0 – 5.0), triethanolamine (0.5 – 2.0), tetranatrium salt of ethylenediaminetetraacetic acids (0,1 – 1,0), silicone emulsion (0,1 – 1,0) and drinking water (up to 100). The disadvantage of this product is a fairly high cost due to the use of an optimized mixture of alkyl glucoside and ethoxylated alcohols (Berol LFG-61) manufactured by Akzo (Sweden). In addition, the use of triethanolamine, which is dangerous in the concentrated state, requires the use of only the finished mixture of industrial production. And it also significantly increases the cost.

The known alkaline detergent-disinfectant [4] for sanitary treatment of milking equipment and dairy equipment containing (in mass %) sodium hydroxide – 5,0, soda ash – 0,5, catamine – 10, sodium hydrosilicate – 4,0 , trilon B – 0,5 and distilled water – 80. The disadvantage of this composition is a significant number of its components, which increases its cost. Moreover, the surfactant (catamine), which is contained as a major component and in a fairly significant amount, has a negative effect on the environment and a specific bad odor. In addition, such disinfection requires strict compliance with the concentration limits, and this complicates the use of composition.

The authors also investigated the well-known alkaline detergent-disinfectant mixture "Syntrol" (type 2) [5]. It is recommended for the washing of dairy industry technological equipment and can be prepared both at the chemical plant and directly at dairy enterprises. Caustic soda (sodium hydroxide) – 26 (mass, %), surfactant (sintanol DS-10) – 2.0 (mass, %), trilon B – 9.0 (mass, %), water – up to 100% are the chemical composition of the alkaline mean.

The disadvantage of this tool is the overestimated concentrations of all components, which is the cause of the thermodynamic instability of the system. As a result, during storage, the

sedimentation process is observed. In addition, this mixture has corrosive aggressiveness to the equipment material and high enough foaming ability. Therefore, the use of this mixture in CIP systems (Clean In Place) can cause damage to the equipment. High concentrations of components are the reason an overpriced cost of the detergent solution.

To solve one of the parts of a series of problems, the authors carried out researches, developed and proposed solutions for washing and disinfection of dairy equipment in the Clean in Place mode (CIP) [2, 6 – 8]. Due to the difficulty of accessing the internal surfaces of the technological equipment of the dairy industry in the CIP mode, these processes of washing and disinfection are the biggest problem.

The cycle of experimental studies carried out by the authors for several years has given a positive result in the creation of competitive detergents that can be used not only in the dairy industry, but also in other areas of the food industry [2, 6 – 8]. Obviously, it was necessary to solve the problem of creating a cheap and high-quality alkaline mean for washing and disinfection of the dairy industry technological equipment, as required by the methodology [1, 5]. But the task of optimizing the conditions of the proposed means to identify more efficient mode of application, including for energy saving, is also very important.

Therefore, the purpose of the first part of our work was to create a cheap alkaline detergent for effective cleaning and disinfection of the interior surfaces of the dairy industry technological equipment in Clean In Place mode (CIP).

The task of the development of the formulation of an effective alkaline detergent for sediments dissolution (hydrolysis of fats and proteins) before treatment with acid solution was the basis of our work.

The purpose of the second part of our work was to optimize the conditions for the use of cheap alkaline mixture, prepared by the authors, for efficient washing and disinfection of the interior surfaces of technological equipment of the dairy industry in CIP- mode (Clean In Place).

The relevance of the work consists in the possible practical solution of the problem of washing and disinfection of the internal surfaces of the dairy industry technological equipment in the automatic mode.

The main benefits are safety when used; the absence of unpleasant odors; the possibility of using tap water; availability of raw materials; ease of preparation; low cost; the possibility of using both large dairy enterprises and small farms.

The object of the research was to study the washing effect of the alkaline mixture in the case of dilution by water in a wide range of concentrations and temperature changes to the permitted values.

The subject of our research was alkaline detergent, developed at the Department of Chemistry of the Poltava National Technical Yuri Kondratyuk University.

Determining the optimal concentration and the minimum temperature at which the washing effect is maintained was the main task of our work.

The invention presented in the work relates to the production of detergents for washing and disinfection of equipment of enterprises of the food industry (internal surfaces of the dairy industry technological equipment). It can be used for the washing of milking machines, various containers for the transportation of milk, pipelines, including the Clean In Place method [1] prior to acid treatment to provide an efficient and economical solution to the washing problem and disinfection of internal surfaces of technological equipment in hard-to-reach places.

Dairy pollutions have specific chemical composition and certain features that determine special methods of sanitization. That is why washing with water and even ordinary detergents is insufficient [5, 9 – 12].

Contaminants that are formed and remain on the surface of equipment by chemical composition are divided into three groups.

1) This is the so-called milk film. The main components of it are fats and proteins. It is contamination remaining from contact with the surface of cold milk.

2) It is pollution in the sediment of soft consistency. Its main chemical composition is calcium phosphate and denatured protein. This kind of sediments is formed after the milk is heated to 80°C.

3) According to the chemical composition of the third group of contaminants – a complex consisting of serum proteins and inorganic substances. They are formed and remain on the surface of the processing equipment after the heat treatment of milk at a temperature higher than 80°C. Their feature is high durability. They can not be destroyed by an increase in temperature. This process only strengthens them [13].

Thus, the nature of pollution and the degree of their strength depend on the temperature and length of processing of dairy raw materials. The chemical composition and properties of sedimentary deposits depend on the acidity of the dairy raw material and the processing temperature. There is a regularity - the greater the acidity of milk, therefore, the amount of polutant sedimentation is the greater in some times [13].

Detergents are used as solutions. They should have the following properties: low surface tension, good wetting, ability to remove milk protein and insoluble calcium salts, emulsify fat residues, have no toxic effects, do not cause corrosion of the equipment, low foam formation and well rinse off the surface of the equipment [14, 15].

Since the main components of pollutants are proteins, fats and inorganic substances in a complex with proteins, it is essential that the washing solutions are alkaline and acidic. Since

proteins and fats are hydrolyzed in a strongly alkaline environment, and complexes of inorganic substances dissolve and remove from the surface of the equipment with acids, then initially the equipment is treated with an alkaline solution, and then acidic mean [5, 9].

Both in the concentrated state and at dilution to the specified concentration, the alkaline solutions must have an appropriate active alkalinity, which is determined by acid-base titration [5].

The problem is solved by the fact that the alkaline detergent proposed by the authors consists of sodium hydroxide, trilon B, syntano DS-10 and water. Such a chemical composition ensures its high activity, effective washing ability and disinfecting properties, does not corrode metal surfaces of equipment. In addition, it does not form foam and sediment when using tap water. The chemical composition of invented and proposed alkaline mean is indicated in [16].

The authors determined the pH of the proposed concentrated alkaline solution is 14.0 and pH= 13.0 at dilutions to the recommended concentrations. The use the mixture of optimally selected concentrations solutions of strong alkali, a complexing agent with a moderate content of surfactant provides a detergent that has a high pH and provides the necessary washing and disinfection effect over a wide range of concentrations.

In the process of detergent preparation, the authors found that the concentration of the solution should be different depending on the type of material equipment, which needs to be cleaned. The technological equipment of dairy enterprises should be made of stainless steel and glass. And these materials are chemically inert to the detergent solution.

The solution density according to the invention at 20°C is 1,210-1,215 (g/cm^3). The solution is transparent, colorless and odorless. Since the solution is non-foaming, it can be used in high pressure at CIP-mode.

In order to the modes optimization of the most effective use of the proposed solution, a series of experiments on the removal of milk contaminants in the form of films (exposure 1 day) applied to plates of food stainless steel was performed by the authors. Contaminated plates were stationary in static mode without mechanical intervention for 15 minutes under the influence of the proposed alkaline detergent and solutions of different degrees of dilution at different exposure temperatures (from 55°C to 80°C) without further treatment in an acid solution according to works [1, 5]. Concentrated solution was primary. Other solutions were prepared from the primary concentrate by dilution with distilled water in ratios of 1:1, 1:2, 1:3, 1:4, 1:5, 1:6, 1:7, 1:8, 1:9, 1:10 and 1:99.

The washing effect of the alkaline detergent was determined by the weight method in accordance with the method [17]. Its essence is that the steel plates with stainless steel of food stamps size 80×40×2 mm are used. After contamination according to the procedure described above, and purification, the obtained results are compared with the reference pure sample, taking into account the final contamination (M). Final contamination (M) is the ratio of the mass of

pollution to the unit area of the contact surface of the sample. The units of measurement are g/cm^2. The mass of pollution is determined by the difference in sample mass with final contamination after cleaning with a detergent and a clean specimen.

The results of experimental studies are presented in Table 1.

Table 1

Investigation of the washing effect by alkaline mean at the temperature of 80°C

№ Sample	Weight of Sample, g	Weight of sample with milk film, g	Weight of milk film, g	Sample area ($\times 10^{-4}$) m^2	Weight of sample after treatment with an alkaline mean, g	Weight of the residue after treatment, g	Final pollu-tion (g/m^2)	Notes
Alkaline mean								
1	5,67265	5,68775	0,01510	7,8	5,67240	-0,00440	0,00	Insignifi-cant reduction of the pure sample mass, complete removal of the film, visually clean surface
Alkaline mean diluted 1:1								
2	6,34510	6,35545	0,01035	7,75	6,34510	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:2								
3	6,16020	6,18175	0,02155	7,68	6,16020	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:3								
4	5,81465	5,83675	0,02210	7,44	5,81465	0,00000	0,00	Complete removal of the film, visually clean

								surface
Alkaline mean diluted 1:4								
5	6,07800	6,08885	0,01085	7,44	6,07800	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:5								
6	5,71360	5,73095	0,01735	6,82	5,71360	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:6								
7	6,02380	6,04475	0,02095	7,75	6,02380	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:7								
8	5,97500	5,99220	0,01720	7,44	5,97500	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:8								
9	6,06950	6,08575	0,01625	7,75	6,06950	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:9								
10	6,22310	6,24505	0,02195	7,75	6,22310	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:10								
11	6,17590	6,19365	0,01775	8,37	6,17590	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:99								
1	6,18430	6,20205	0,01775	8,12	6,18430	0,00000	0,00	Complete

2								removal of the film, visually clean surface

Source: Author's experimental research

Thus, the washing effect occurs throughout the range of dilutions. The authors investigated the washing effect of the proposed alkaline solution without further treatment in an acid solution at the lowest recommended temperatures, respectively [1, 5].

The results of experimental studies are presented in Table 2.

Table 2

Investigation of the washing effect by alkaline mean at the temperature of 55°C

№ Sample	Weight of Sample, g	Weight of sample with milk film, g	Weight of milk film, g	Sample area ($\times 10^{-4}$) m^2	Weight of sample after treatment with an alkaline mean, g	Weight of the residue after treatment, g	Final pollu-tion (g/m^2)	Notes
Alkaline mean								
1	5,67240	5,68385	0,01145	7,8	5,67240	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:1								
2	6,34510	6,36175	0,01665	7,75	6,34510	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:2								
3	6,16020	6,18190	0,02170	7,68	6,16020	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:3								
4	5,81465	5,83575	0,02110	7,44	5,81465	0,00000	0,00	Complete removal of the film,

								visually clean surface
Alkaline mean diluted 1:4								
5	6,07800	6,10230	0,02430	7,44	6,07800	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:5								
6	5,71360	5,74745	0,03385	6,82	5,71360	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:6								
7	6,02380	6,04925	0,02545	7,75	6,02391	0,00012	0,15	A slight increase in mass, a feeling of the oily surface to the touch
Alkaline mean diluted 1:7								
8	5,97500	5,99640	0,02140	7,44	5,97520	0,00020	0,27	A slight increase in mass, a feeling of the oily surface to the touch
Alkaline mean diluted 1:8								
9	6,06950	6,08425	0,01475	7,75	6,06980	0,00030	0,39	A slight increase in mass, a feeling of the oily surface to the touch
Alkaline mean diluted 1:9								
10	6,22310	6,23735	0,01425	7,75	6,22350	0,00040	0,52	A slight increase in mass, a feeling of the oily surface to the touch
Alkaline mean diluted 1:10								
11	6,17590	6,19720	0,02130	8,37	6,17650	0,00060	0,72	A slight increase in

								mass, a feeling of the oily surface to the touch
Alkaline mean diluted 1:99								
1 2	6,18430	6,20205	0,01775	8,12	6,18559	0,00130	1,60	A slight increase in mass, a feeling of the oily surface to the touch

Source: Author's experimental research

Therefore, the washing effect occurs even at the lowest recommended temperature without acid treatment. This indicates the high efficiency of the proposed alkaline mean.

The authors performed a series of experimental studies of the washing effect of the proposed alkaline mean without further treatment in an acid solution at intermediate temperatures at the largest dilutions.

The results of experimental studies at the temperature of 70°C are presented in Table 3.

Table 3

Investigation of the washing effect by alkaline mean at the temperature of 70°C

№ Sample	Weight of Sample, g	Weight of sample with milk film, g	Weight of milk film, g	Sample area ($\times 10^{-4}$) m^2	Weight of sample after treatment with an alkaline mean, g	Weight of the residue after treatment, g	Final pollu-tion (g/m^2)	Notes
Alkaline mean diluted 1:6								
1	6,22310	6,24458	0,02148	7,75	6,24458	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:7								
2	5,97500	5,99545	0,02045	7,44	5,99545	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:8								

3	5,71360	5,73465	0,02105	6,82	5,73465	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:9								
4	5,81465	5,83579	0,02114	7,44	5,83579	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:10								
5	6,34510	6,36635	0,02125	7,75	6,34533	0,00023	0,30	A feeling of the oily surface to the touch
Alkaline mean diluted 1:99								
6	6,18430	6,20205	0,01775	8,12	6,18487	0,00057	0,70	A feeling of the oily surface to the touch

Source: Author's experimental research

The results of experimental studies at the temperature of 60°C are presented in Table 4.

Table 4

Investigation of the washing effect by alkaline mean at the temperature of 60°C

№ Sample	Weight of Sample, g	Weight of sample with milk film, g	Weight of milk film, g	Sample area ($\times 10^{-4}$) m^2	Weight of sample after treatment with an alkaline mean, g	Weight of the residue after treatment, g	Final pollu-tion (g/m^2)	Notes
Alkaline mean diluted 1:6								
1	6,17590	6,19602	0,02012	8,37	6,19602	0,00000	0,00	Complete removal of the film, visually clean surface
Alkaline mean diluted 1:7								
2	6,06950	6,08965	0,02015	7,75	6,06971	0,00021	0,27	A feeling of the oily surface to the touch

Alkaline mean diluted 1:8								
3	6,02380	6,04388	0,02008	7,55	6,04418	0,00030	0,39	A feeling of the oily surface to the touch
Alkaline mean diluted 1:9								
4	6,07800	6,09904	0,02104	7,44	6,07839	0,00039	0,52	A feeling of the oily surface to the touch
Alkaline mean diluted 1:10								
5	6,16020	6,18122	0,02102	7,68	6,16075	0,00055	0,72	A feeling of the oily surface to the touch
Alkaline mean diluted 1:99								
6	6,16020	6,20445	0,02015	8,12	6,0856	0,00130	1,60	A feeling of the oily surface to the touch

Source: Author's experimental research

Obviously, there is an effective washing of the milk film in static conditions at the highest dilutions.

The 100% efficiency of the proposed detergent alkaline product is confirmed by the results presented in Table 1.

The cost of 1 liter of alkaline means for washing and disinfection of milking machines by the method of a detachable circulating sink is 16 UAH (~0.57 USD).

The method of using the proposed detergent solution is standard [5] and energy-saving. The main stages of washing and disinfection are as follows [5]:

– the equipment outside is rinsed with water from the hose;

– residues of milk and dairy products are washed with warm (room temperature) or cold tap water (the duration of rinsing depending on the remnants on the surface of the equipment lasts 5-7 minutes);

– the equipment is washed with alkaline solution at a temperature of 55-80°C (duration of alkaline washing depending on the type of equipment is on average 10-15 minutes);

– after washing with an alkaline solution, the equipment is rinsed with warm or hot water to remove alkali residues for 5-15 minutes. The effectiveness of rinsing is checked for the presence of alkali in washing waters (by phenolphthalein).

After rinsing from the remnants of the alkaline solution, the equipment is washed with an acid solution (temperature 70-85°C, duration 25-30 min) for the purpose of prevention, as well as for disinfection and removal of insoluble sediments.

Conclusions:

1. The alkaline composition formulae for cleaning and disinfection of milking units and milk processing equipment in automatic mode (Clean in Place) have been invented.

2. The main benefits of the proposed acidic mixture are safety when used; the absence of sharp and unpleasant odors while meeting all the requirements for cleaning and disinfectants; the possibility of using tap water; availability of raw materials; ease of preparation; low cost; the possibility of using both large dairy enterprises and small farms.

3. An alkaline mixture for cleaning and disinfection of milking machines by CIP method was investigated.

4. The optimal modes of efficient use of alkaline detergent have been developed and proposed.

5. It was found that for the complete cleaning of a fresh milk film (1 day) the washing effect occurs throughout the range of dilutions (t=80°C).

6. At minimum of recommended temperatures (t=55°C) the complete cleaning of a fresh milk film (1 day) occurs before dilution to 1: 5, inclusive.

7. At a temperature of t = 70°C the maximum dilution of 1: 9 is permissible. There is also a complete removal of the precipitate without further treatment with an acid solution.

8. When washing at a temperature of 60 ° C, the use of a 1: 6 dilution solution is acceptable.

9. It is necessary to optimize the conditions of use of the invented and recommended alkaline and acid [6] solutions. The result of greater energy efficiency of their complex application according to the methodology is expected.

With all these advantages and low cost, it can be prepared directly at enterprises before use, can be applied on both small farms and large dairy enterprises. The proposed alkaline means allows solving the problems of washing and disinfection of technological equipment of the dairy industry in CIP mode.

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