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ORGANIZATION OF WASHING AND DISINFECTION DURING THE PRODUCTION PROCESS IN MEAT INDUSTRY

Agnieszka Bilska

Poznań University of Life Sciences, Poznan, Poland

ABSTRACT. Background: Washing and disinfection in the food industry are major operations, affecting safety and stability of final products and therefore they are critical point of the production process. The proper organization of this part of the process ensures significantly the efficiency of the whole process.
Methods: The paper presents the process of washing and disinfection as well as control methods to assess their efficiency in meat processing plants. Their properties and application of washing and washing and disinfecting agents were characterized. Requirements imposed on washing and disinfecting agents used in the food industry are reported.
Conclusions: It is essential to have knowledge on problems related to organization and optimization of cleaning process in order to properly organize the whole production processes in meat industry.

Key words: washing, disinfection, washing agents, disinfectants, washing methods, disinfection methods, organization of production process.

INTRODUCTION

Washing and disinfection of both machines and equipment, and production facilities is essential for effective prevention of health hazards related with food. This process ensures hygienic production conditions and clean, pleasant and safe working conditions. It is connected with removal of food potentially attracting rodents and other pests, it prevents breakdowns and has a positive effect on potential customers. Left production residue provides a substrate for the development of microorganisms, but it may also become a source of biological infestation and contamination with toxic or harmful substances, formed as a result of degradation of this residue (oxidation, hydrolysis, pyrolysis). For this reason washing and disinfection processes in food industry plants aim at the maintenance of an appropriate hygienic status, both in technological equipment and production facilities. Cleanliness and hygiene have to be maintained in food production within the Good Hygienic Practice (GHP), which is the foundation for the principles of the HACCP system. Systematic, thoroughly performed washing and disinfection processes using effective agents, techniques and equipment have a significant effect on food safety.

WASHING, DISINFECTION - DEFINITIONS, OBJECTIVES, LEGAL ASPECT

Washing is a procedure consisting in thorough removal of soiling from surfaces subjected to this process, typically using physical agents such as e.g. brushing, rinsing, high pressure, low pressure, use of chemicals e.g. organic acids [Kołożyn-Krajewska 2001,

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Özbay and Demirer 2007, Fryer and Asteriadou 2009, Diakun and Mierzejewska 2012, Diakun 2013, Koo et al. 2013].

Disinfection consists in selective elimination of undesirable microorganisms causing spoilage of food products or disturbing the appropriate course of the technological process, first of all pathogens, dangerous for human and animal health. Disinfection destroys microorganisms thanks to its effect on the structure or metabolism of microorganisms [Kołożyn-Krajewska 2001, Olesiak and Stępniak 2012]. Washing and disinfection of machines and equipment aim at the establishment of an adequate standard of production hygiene, and thus providing appropriate quality of products. Effectiveness of disinfection depends on such factors as duration of the process and concentration of the disinfectant [Lewicki 2005, 2006, Olesiak and Stępniak 2012]. These parameters are provided on labels by producers of biocides. Offered high quality disinfectants and washing and disinfecting agents are most frequently based on several active substances. Effectiveness of these substances is defined using the degree of reduction of microbial contamination and the bactericidal and fungicidal effect is specified according to the standards PN-EN 13697, PN-EN 1276 and PN-EN 1650. Disinfection effectiveness is confirmed when the microbial count is reduced, depending on the standard by 99.9% (3 log reduction) up to 99.999% (5 log reduction) [Sienkiewicz 2013].

Effectiveness of washing and disinfection in meat industry plants may also be assessed based on the Polish Standard PN-A-82055-19 - Meat and processed meat products. Microbiological analyses. Determination of microbial contamination of surfaces of equipment, furnishings, facilities as well as packaging and workers' hands [Boliński and Bolińska 2003].

The Ordinance of the Minister of Health of 19 December 2002 on hygienic and sanitary requirements in processing plants and requirements concerning hygiene in production and turnover of items and products to be used with these items is the essential legal act binding for food producers and distributors as well as inspection agencies, which specifically requires the application of washing and disinfection procedures in the food industry. This act regulates principles of washing and disinfection and it refers to the problem of disinfectants and effectiveness of the above mentioned procedures.

The Act of 25 August 2006 on food and nutrition safety [the Journal of Law Dziennik Ustaw Dz.U. 06.171.1225 2006) is the primary legal act concerning food. It specifies health requirements for food and requirements concerning principles of hygiene, and it regulates issues connected with official food control.

Specific veterinary conditions required in meat processing of slaughter animals and storage of processed meat products are provided by the Ordinance of the Minister of Agriculture and Rural Development of 18 March 2004 [the Journal of Law Dziennik Ustaw Dz.U.04.50.489].

Since 1 January 2006 uniform food regulations have been binding in all EU member countries, constituting the so-called Hygiene Package and comprising four Resolutions establishing principles of foodstuff hygiene, as well as principles of activities of respective authorities supervising operators of the food sector.

STAGES OF WASHING AND DISINFECTION

The process of washing and disinfection in meat processing plants is performed in the night, i.e. between the last and the first shifts. In turn, individual machines of the production line (grinders, cutters), some elements of equipment in contact with the product (the rail belt) and auxiliary implements (knives, containers) should be cleaned more frequently. This may be caused by a change in the production profile, e.g. the type of meat being cut or upon the completion of production of a given batch.

Primary stages of washing and disinfection:

1. Preparation or preliminary rinsing - to remove bigger fragments of the product from surfaces, as well as some residue loosely attached to the surface. The primary aim of the operation is to provide appropriate conditions for washing, reduce to the minimum the dilution of washing liquids and limit the participation of washing agents in reactions with product components. In this process, lasting for only several seconds, approx. 30% residue is removed.
2. Washing procedure - removal of soiling and residue left after the production process from machine and equipment surfaces. It is important to perform it thoroughly, as it may have a tremendous effect on potential secondary contamination.
3. Rinsing - to remove residue of previously applied chemicals and preparation of residue surface for contact with the next working substances, tearing off of a dirt layer, revealing microorganisms (biofilm)
4. Disinfection - penetration to biofilm and inactivation of microorganisms. Disinfection may be performed only on thoroughly washed surfaces, using preparations based on various types of active substances, of which each has its own limitations and advantages. It is not recommended to apply universal washing and disinfecting preparations, which - while reducing the time of the whole process - markedly lower its effectiveness,
5. Final rinsing - it has to be performed using drinking water, the quality of this water determines the possibility of secondary contamination of washed and properly disinfected surfaces [Kołożyn-Krajewska 2001, Lewicki 2005, 2006, Piepiórka et al. 2009, Piepiórka and Wlazło 2010]

DIVISION OF WASHING METHODS

Washing techniques and methods may be classified in several ways, e.g. depending on:

- the type of washed objects (raw materials - soft, hard; packaging - direct, indirect; surfaces - facilities, equipment; equipment - non-disassembled, disassembled; installations; equipment and technological tools)
- character of the effect of washing agents (mechanical, chemical, temperature, time)
- manner of effect on washed surface (hydro-mechanical, manual, with a considerable effect of chemicals - diagram 1)
- organisation (the type of washed objects - single, flow, mass, and control - by an operator, automatic, computer-controlled)
- type of equipment (washing in pools, chamber washers, tunnel washers, CIP - Cleaning In Place - in the closed or open systems, COP - Cleaning Out of Place - mechanically assisted or manual) [Diakun 2013]

Manual washing should be applied sporadically and only in those cases, when mechanical washing does not yield required results. It may be used for small machines and equipment, which incorporation in the mechanical washing system is impossible or non-viable economically. In most cases it consists in the disassembly of equipment, mechanical removal of product residue and soiling, rinsing of washed parts and their assembly. In the course of washing mechanical brushes or pressure installations applying foam or gel may be used. The possibility of visual assessment of performed work guarantees that it was properly performed. However, this method requires considerable input of human labour as well as consumption of water and chemicals and due to the subjective evaluation of the performed washing operation, it also requires a well-organised control of production hygiene [Piepiórka-Stepuk 2011, Diakun 2013].

Mechanical washing may be performed in the manual or automatic control system. In most cases washing is performed by spraying with water or its solutions with chemicals and rinsing with water. Thus the action on the washed surface may be defined as hydromechanical [Diakun 2013].

Washing in an open system is used in the case of highly soiled surfaces and production lines organised so that it is impossible to wash them using a central washing station. In this system the washing solutions are used only once and upon the completion of the washing process they are discharged to the sewage

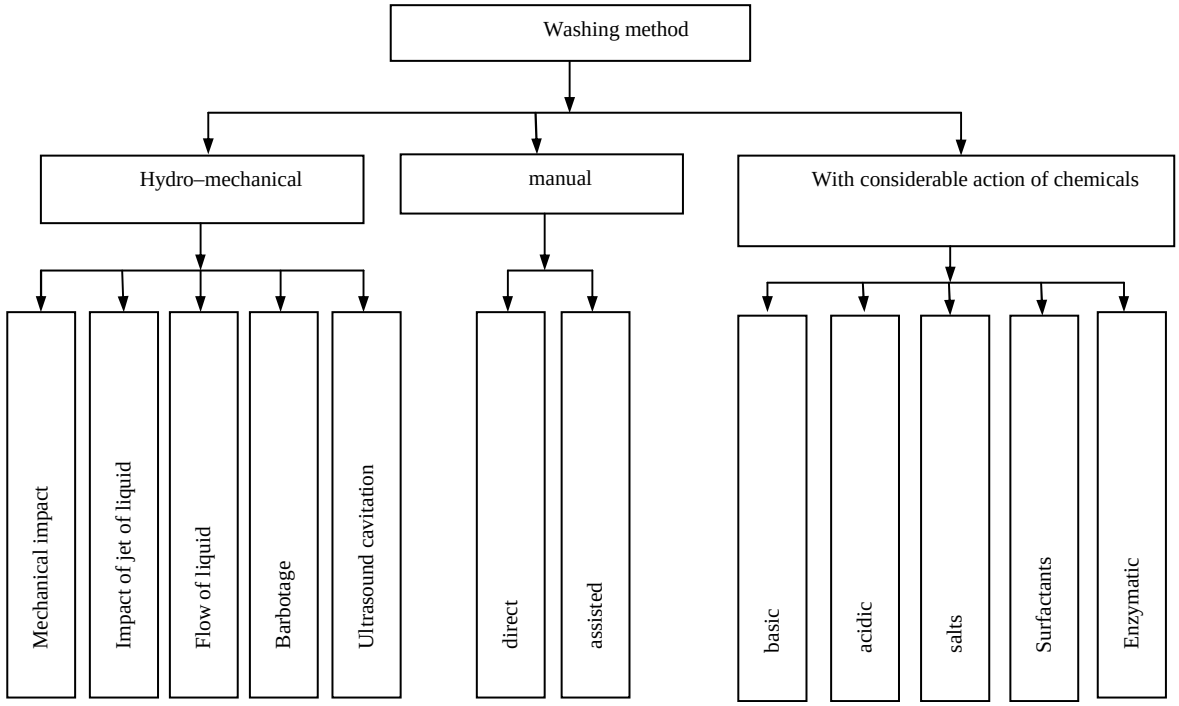
system. When the detergency of the solution is not completely depleted in the process, the solution is collected in a tank and used in preliminary rinsing in the next washing cycle [Lewicki 2005].

Washing in the closed cycle (CIP - Cleaning In Place) facilitates repeated use of washing agents. Washing in the CIP system is performed with no installation disassembly (the installation is closed), thus it is difficult to verify washing quality. In order to provide effective washing and guarantee surface cleanliness after this process a significant role is played by washing factors, i.e. duration of the washing process, temperature of the washing liquid, washing chemicals and their concentration, mechanical energy expressed as the action of the liquid on walls of washed elements and local shear stresses [Lelievre 2002, Lewicki 2005, Bremer et al. 2006, Blel et al. 2007, Piepiórka and Diakun 2007, Diakun 2011, Piepiórka-Stepuk and Diakun 2012, Srey et al. 2013]. For example, dirt may be removed from tanks thanks to:

- free flow of the liquid over the wall (e.g. when washing tanks previously holding fruit juice immediately after they have been emptied)

or

- the impact of the jet of the liquid flowing out of the nozzle with high velocity (when contamination is difficult to remove, e.g. in a tank previously holding fat).



Source: Diakun 2013

Fig. 1. Classification of washing methods in terms of the manner of action on washed surface
Rys. 1. Klasyfikacja metod mycia ze względu na sposób oddziaływania na mytą powierzchnię

The washing process with a repeated use of washing solutions and following a present programme has to be extremely thoroughly controlled. Each washing process had to make the surfaces reach a specific cleanliness status defined physically, chemically and microbiologically.

The course of the washing process in the CIP system is controlled using programmers or microprocessors. In programming devices the sequence of actions and their parameters are found in the memory of the module, while the display presents the flow chart and the currently performed action [Piepiórka and Diakun 2007, Diakun 2011, Srey et al. 2013].

Dry washing is limited to precipitation, suction, brushing and wiping off the contaminants. Dry washing generally precedes wet washing.

Wet washing is a complex process, consisting in preliminary rinsing, main washing - mechanically assisted and/or with elevated temperature, rinsing in order to remove the washing agent. The applied medium is water or water solutions of washing agents.

Washing using the jet of washing liquid is divided into: normal washing (low pressure - pressure up to 25 bars) and high pressure - run at a pressure from 25 to 120 bars. High pressure facilitates removal of contaminants. Moreover, in the case of this method we need to ensure that no mechanical damage, secondary infestation or aerosols are formed. Water bubbles transport microorganisms, which after some time are deposited and contaminate equipment. However, a much better solution is to combine low pressure rinsing with foam generated by the system e.g. to wash external surfaces [Piepiórka et al. 2009].

Such washing methods as foaming, spraying and gelling are mainly used in the meat industry. These washing methods are frequently used to wash walls, installations and their direct environment. Other special washing methods involve steam up to 140°C, gases, i.e. oxygen, or mechanical systems (scrubbing systems).

WASHING AND DISINFECTING AGENTS AND THEIR CHARACTERISTICS

Many chemicals certified by the National Institute of Hygiene for washing and disinfection of surfaces in contact with food are commercially available. However, these agents need to be selected according to needs, considering the type and amount of contaminants and the specific load of organic substances. Unfortunately, there are no universal washing agents. Alkaline or neutral agents are sufficient to eliminate loads of organic substances, while acid agents are required to remove salt and calcium residue. However, while using acid washing agents we need to consider their effect on production equipment. Corrosive substances may within a short time destroy the plant equipment. It is also important for those preparations to be relatively cheap. The new Regulation of the European Parliament and the Council (EU) (no. 528/2012 of 22 May 2012 - the Official Journal of the European Union L 2012.167.1) concerning the making available on the market and use of biocidal products entered into force on 1 September 2013. This Regulation (BPR, Regulation (EU) no. 528/2012) pertains to the introduction to turnover and application of biocidal products, which are used to protect humans, animals, materials or products against harmful organisms such as pests or bacteria thanks to the use of active substances contained in the biocidal product.

Post-production contamination varies in character and constitutes a mixture of organic and mineral compounds. In order to provide surfaces which are physically and microbiologically clean we need to use substances of various chemical character or their mixtures. When applying disinfecting preparations we need first to identify the proliferating microflora. The mechanism of disinfectant action is connected with the disturbed function of the cytoplasmic membrane, protein denaturation, degradation of nucleic acids, oxidation of sulfhydryl groups in protein structures or formation of stable bonds with other compounds [Piepiórka 2008, Koziróg 2012]. However, serious problems may arise in the case of rough or scratched surfaces or when washing and disinfection processes are performed inappropriately. In such a case on these surfaces biofilms may be formed, i.e. complex microbial structures, surrounded by a layer of mucus, showing adhesion to biotic and abiotic surfaces. In food industry biofilm infestation of food products and surfaces in contact with food may cause food spoilage and consumer infections [Piepiórka 2008, Shi and Zhu 2009, Simoes et al. 2010, Kołwzan 2011, Myszka and Czaczyk 2011, Koziróg 2012, Dzwolak 2013, Srey et al. 2013]. Bacterial cells under the protective biofilm layer are over 1000 times more resistant to the action of disinfecting agents

than cells in the planktonic state. They may be resistant to the action of such agents as bases, iodophors, phenols and quaternary ammonium compounds. To reduce or eliminate biofilms from working surfaces the most frequently used procedures include:

- physical processes - mechanical action (scrubbing, scraping), thermal processes (hot water, hot air), high pressure washing, pulsation laser rays, UV radiation, pulsed electric field, ultrasound, radiation processing
- chemical processes - electrolised oxidation water (EO), ozone (gas and ozonated water), ethylenediaminetetraacetic acid (EDTA), peracetic acid, sodium oxochlorate, peroxides (hydorgen peroxide, potassium tetraoxomanganate), chelating compounds
- biological processes - antagonistic bacteria, bacteriophages, bacteriocins (nisin, etc.), enzymes (α-amylase, glucoamylase and cellulases) [Piepiórka 2008, Simoes et al. 2010, Dzwolak 2013, Srey et al. 2013]

In practice disinfection is most frequently performed by a chemical method using chemicals. Since washing agents often exhibit bactericidal action, the washing process itself destroys most microflora found on washed surfaces. Obviously also those microorganisms, which survived the washing process, need to be destroyed. For this purpose substances belonging to different chemical groups are applied. The most important include:

- chlorine compounds. These are sodium oxochlorate, oxochloric acid, sodium oxochlorate and chloramines. These compounds are characterised by good water solubility, they are stable at room temperature and exhibit low sensitivity to light. They have a relatively wide spectrum of action against microorganisms. Upon contact with microbial cells they released ionised oxygen, which denatures proteins and destroy structures of cytoplasmic membrane and deactivates enzymes containing the -SH group. Water applied in disinfection leads to cell death. Sodium oxochlorate is used most often. It has strong oxidising properties, but its high chemical activity leads to corrosity in equipment made from metal. It also exhibits an irritant action towards the respiratory tract. Concentration of active chlorine in an alkaline solution should range from 150 to 200 ppm, while in an acid medium as little as 80 - 100 ppm is sufficient in an acid environment [Piepiórka 2008, Sienkiewicz 2012, Srey et al. 2013].
- Chlorine dioxide is effective in the control of bacteria and viruses. In the first place it destroys the cell membrane and next the nucleus of bacteria. It is used in the disinfection of surfaces in contact with food, in indoor and outdoor washers, in washing systems, in rinsing, in treatment of drinking and processing water, in washing and disinfection of meat, poultry carcasses, vegetables, fruit and in fish processing [Anonymous 2006].
- Quaternary ammonium compounds (QAC), i.e. cationic surfactants. These compounds exhibit very good microbial effectiveness, good water solubility and low toxicity. They alter permeability of cell walls and membranes in microorganisms, reduce surface tension, act within a broad range of pH values, exhibit good wettability and do not case corrosion. They are stable both as working solutions and in the concentrated form. Their activity decreases considerably in the presence in the medium of such contaminants as proteins, fats, milk and soap [Sienkiewicz 2012].
- Peroxide compounds. This group comprises such compounds as hydrogen peroxide, peracetic acid and potassium persulfate. This major property is connected with their effectiveness against both vegetative and sporulating forms. They act not only against bacteria, but also viruses, Koch's bacilli and fungi. Their other advantage is related with the fact that microorganisms do not acquire immunity against them. Microbial cells do not develop resistance mechanisms towards their action. These substances are not corrosive to steel or aluminium, they are readily leached and are biodegradable. Products of their degradation do not pose a hazard in relation to food products.
- Peracetic acid is used most often, acting against vegetative and sporulating forms,

both against fungi and viruses. Its action consists in:

- Oxidation of -SH groups of proteins to disulfate bridges
- Oxidation of double bonds found in the cell membranes [Olesiak and Stępniak 2012].

Mechanism of destruction of microorganisms consists in the release of active oxygen, which destroys both proteins and fats or nucleic acids [Olesiak and Stępniak 2012, Sienkiewicz 2013, Srey et al. 2013]. Peracetic acid is composed of acetic acid, oxygen, water and it may be used in the food industry, even under conditions when rinsing after disinfection is impossible. It has weak foaming properties. It is one of the most effective active substances in the control of biofilms. Another advantage is also connected with its complete biodegradability and good activity at low temperatures [Piepiórka 2008, Olesiak and Stępniak 2012, Sienkiewicz 2013, Srey et al. 2013].

- Ozone has strong oxidising properties, resulting from the high redox potential. Thus susceptibility to the action of ozone is observed in gram-positive and gram-negative bacteria, viruses, yeasts, spores and vegetative cells. It degrades more rapidly in water than in oxygen or air. Most metals are susceptible to the action of ozone. It does not cause the formation or increased resistance of microorganisms. It may be used to wash plastic containers used in storage and transport of meat [Krosowiak et al. 2007, Pascual et al. 2007, Li et al. 2011, Srey et al. 2013]
- Alcohols. Disinfecting agents are produced mainly on the basis of ethanol and propanol. The greatest activity is observed at a concentration of 50 - 70%. When applying them we may eliminate the stage of rinsing of disinfected facilities with water. They cause first of all protein denaturation and lipid dissolution.
- Aldehydes. The most frequently used include formaldehyde and glutaraldehyde. Due to their toxicity they are not used for surfaces, which are in contact with food [Olesiak and Stępniak 2012].

Disinfection may be also performed using physical factors. It consists in the use of heat energy and the mechanical action of a jet of liquid. In a limited number of cases ultraviolet radiation is used to sterilise surfaces.

Sterilisation of equipment using heat is performed mainly using saturated steam at a temperature of 120°C and lasting for 10-15 minutes. In specific cases hot air is used. Then the process lasts for 60 minutes at a temperature of 160°C. The use of high temperatures is applied e.g. to sterilise knives, saws or axes. Disadvantages of the thermal method include its high energy and time consumption [Piepiórka and Wlazło 2010].

UV radiation has found more extensive applications and is used for general disinfection of tables, tanks, tools, walls, ceilings and air in production facilities. Biocidal properties are found for radiation with a wavelength of 240-280 nm. It acts on vegetative and sporulating forms of bacteria. Vegetative forms of microorganisms from the log growth phase are most sensitive to ultraviolet radiation. Effectiveness of UV radiation depends on the radiation dose, the physiological phase of the microorganism and on conditions found immediately after irradiation [Piepiórka and Wlazło 2010, Omyliński 2013].

Mechanical action of a jet of liquid consists in targeting a jet of pure fresh water under high pressure onto the cleaned surface. Most typically two ranges of water pressure are applied when cleaning with this method:

- Cleaning with a jet of water under high pressure (68 MPa - 170 MPa)
- Cleaning with a jet of water under very high pressure (over 170 MPa).

Disinfection using ultrasound depends on the intensity of ultrasounds, including the generation of cavitation and on the temperature of the liquid and the chemical structure of the washing solution. Good results are obtained using ultrasound with a frequency of 20 - 150 Hz [Piepiórka and Wlazło 2010, Srey et al. 2013].

STUDIES ON THE EFFECTIVENESS OF WASHING AND DISINFECTION

Washing and disinfection of machines, equipment, production facilities, warehouses as well as changing rooms, corridors and toilets for employees aims at providing adequate hygiene in meat processing plants, which is essential to ensure safety of the final product. Effectiveness of washing and disinfection is influenced by the duration of the washing cycle, temperature, conductivity, pH of washing agents, flow velocity, pressure, etc. Despite thorough control of these parameters and repeatability of washing processes it is not certain whether the cleaned surface is clean. Thus it has to be verified whether machines, equipment and production facilities have been properly washed and whether they will not constitute a source of contamination for the final product. This may be ensured thanks to the application of the following methods:

- Visual assessment of cleanliness of facilities and equipment; it is a qualitative and subjective evaluation
- optical (turbidimetric) method consisting in the measurement of the degree of turbidity of the washing solution
- electrical method, which consists in the measurement of electric conductivity of the flowing liquid
- microbiological methods consisting in:
  - collection of smears (from production surfaces, hands), preparation of cultures and verification of counts of growing colonies
  - assessment of air purity using spontaneous particle sedimentation
  - outwashing of microorganisms from tanks, pipes - the method is based on the flushing with a specific amount of sterile liquid, from which quantitative cultures are next prepared on general or selective media
  - preparation of agar blots - the assay consists in blotting surfaces of tested materials on solidified medium and incubation of cultures under adequate conditions. Results are given per unit area of the surfaces [Lewicki 2005, 2006, Piepiórka 2009, Palka 2009].
  - determination of ATP concentration - determination of the level of adenosinetriphosphate by biolumine-scence. This method uses the common presence of ATP in all plant and animal cells as well as microorganisms. The presence of ATP in samples collected in order to asses the cleanliness status in a processing plant indicates the existence of organic contamination - plant and animal residue as well as microorganisms. Testing results from the ATP method are obtained within approx. a quarter of an hour [Szczawiński and Szczawińska 2002, Lewicki 2006]

CONCLUDING REMARKS

The washing and disinfection process, extremely important for the maintenance of high production hygiene, in itself may constitute a specific hazard for the quality of the final product. Poorly washed surfaces constitute a source of chemical and microbiological contamination of the material, while leaking valves or a too short rinsing process may lead to contamination with washing and disinfecting agents. However, it needs to be stressed that the currently applied design solutions as well as washing agents ensure high effectiveness and safety of the washing and disinfection process. If in the production process food is contaminated as a result of the applied washing process, it is a result of simple negligence and a lack of maintenance of machines and equipment. Due to the rare, but still occurring failure of equipment, as well as wear and tear of specific structural elements, the washing and disinfection process should be treated as a critical control point in food safety and quality assurance systems

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ORGANIZACJA MYCIA I DEZYNFEKCJI W TRAKCIE PROCESU PRODUKCYJNEGO W PRZEMYŚLE MIĘSNYM

STRESZCZENIE. **Wstęp:** Mycie i dezynfekcja w przemyśle spożywczym są jednymi z ważniejszych operacji, które mają wpływ na bezpieczeństwo i trwałość gotowych produktów, dlatego też stanowią punkty krytyczne procesu produkcji.
Metody: W pracy przedstawiono proces mycia i dezynfekcji oraz metody kontroli oceny ich skuteczności działania w zakładach przemysłu mięsnego. Scharakteryzowano właściwości oraz zastosowanie środków myjących i myjąco - dezynfekujących. Podano wymagania stawiane środkom myjącym i dezynfekującym stosowanym w przemyśle spożywczym.
Wnioski: Znajomość tych zagadnień jest istotna dla prawidłowej organizacji oraz optymalizacji całości procesu produkcyjnego w przemyśle mięsnym.

Słowa kluczowe: mycie, dezynfekcja, środki myjące, środki dezynfekujące, metody mycia, metody dezynfekcji, organizacja procesu produkcyjnego.

ORGANISATION DES WASCH- UND DESINFEKTIONSPROZESSES IN DER FLEISCHVERARBEITENDEN INDUSTRIE

ZUSAMMENFASSUNG. Einleitung: Waschen und Desinfektion stellen in der fleischverarbeitenden Industrie die wichtigsten, die Qualitätssicherung und Lebensdauer von Fertigprodukten beeinflussenden Operationen innerhalb des Produktionsprozesses dar. Daher machen sie kritische Punkte innerhalb des betreffenden Produktionsprozesses aus.
Methoden: Im Rahmen der vorliegenden Arbeit wurden die Prozesse des Waschens und der Desinfektion sowie die Methoden der Kontrolle deren Wirksamkeit in Unternehmen der fleischverarbeitenden Industrie dargestellt. Dabei wurden Eigenschaften und die Anwendung von Wasch- und Wasch- und Desinfektionsmitteln charakterisiert. Es wurden die an die in der fleischverarbeitenden Industrie angewendeten Wasch- und Desinfektionsmittel gestellten Anforderungen angegeben.
Ergebnisse: Kenntnis dieser Problemstellungen ist unentbehrlich für die richtige Organisation und die Optimierung des gesamten Produktionsprozesses in Unternehmen der fleischverarbeitenden Industrie.

Codewörter: Waschen, Desinfektion, Waschmittel, Desinfektionsmittel, Waschmethoden, Desinfektionsmethoden, Organisation des Produktionsprozesses

Agnieszka Bilska
Institute of Meat Technology
Poznań University of Life Sciences
ul. Wojska Polskiego 31
60 - 624 Poznań, Poland
e-mail: abilska@up.poznan.pl