doi: 10.7251/ZSAN2302061D **Review paper**

INFLUENCE OF CLEANING AND DISINFECTION IN PRODUCTION FACILITIES ON THE MICROBIOLOGICAL QUALITY OF FOOD*

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Abstract: *Good hygiene practices reduce the possibility of food contamination by pathogenic and spoilage microorganisms. During the production process, surfaces are contaminated with various types of physical, chemical, and microbiological pollutants. Microorganisms are a special problem because they grow under suitable conditions and produce metabolites that have an impact on the health safety of food and/or impair the quality of food. A huge challenge in the food industry is the formation of a biofilm, which represents a community of microorganisms that grow and develop embedded in a self-produced matrix of extracellular polymeric substances. In the case of production processes for which the formation of biofilms is characteristic or possible, thorough cleaning and disinfection of surfaces are preventive to the formation of biofilms. The effectiveness of applying good hygiene practice procedures is reflected in the microbiological quality of surfaces that come into contact with food and the microbiological quality of food. The microbiological quality of surfaces that come into contact with food is usually assessed through the total number of microorganisms and/or the detection of the presence of pathogenic or conditionally pathogenic microorganisms. Two types of microbiological food criteria apply to food, including criteria for pathogenic microorganisms and indicator organisms. The food safety criteria determine the acceptability of a product or batch (lot) of product and apply to food placed on the market during its shelf-life. Process hygiene criteria determine the acceptability of the process and are applied during the production process. Individual microorganisms, groups of microorganisms or their toxins to be tested, sampling plan, and microbiological criteria are defined within national and international regulations. When the food safety criteria are not met, the food is a source of health-threatening microorganisms and must be withdrawn from the market. In the event of unsatisfactory results as regards process hygiene criteria, it is necessary to initiate corrective action and monitor its effectiveness. Although there are different ways and sources of food contamination, the implementation of sanitary procedures in food production, handling, and distribution facilities, is a necessary contribution to food health safety and to food quality assurance.*

Key words: *cleaning, disinfection, food, microbiological quality*

Introduction

Good Manufacturing Practice (GMP) is a set of procedures that manage working environment conditions and provides a basis for the production of safe food

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products. It ensures that the production facilities and processes have the necessary conditions to prevent potential hazards from contaminating foods [1]. Regulatory control of GMP began in 1938 when the United States introduced the Food, Drug and Cosmetic Act, which established registration controls and a factory inspection system. The phrase good manufacturing practice was first used in the 1962 Kefauver Harris amendment, but it was not used until the 1970s and 1980s, when GMP concepts really became the focus of regulatory attention in most countries [2]. According to Jarvis [3], the topic “good manufacturing practice” describes the key requirements for all aspects of commercial food production, storage, and distribution necessary to ensure product health safety, product quality, and the fulfilment of customer expectations. The above implies the application of defined principles and practices in the organization and management of the entity in the food business, including employee training, provision of means for production and storage (space and equipment), quality assurance, new product development, legal regulations, and product distribution.

Good Hygienic Practice (GHP) is a set of procedures that manage the hygiene of the working environment and provides a basis for the production of safe food products.

The GMP and GHP programs consist of a series of recommendations that should be implemented at all points of the food chain in order to prevent its contamination by biological, chemical, or physical agents.

The quality assurance system refers to ISO 9001 and GMP, the food safety assurance system refers to ISO 22000 and HACCP. The ISO 22000 International Standard meets the specific requirements to achieve food safety based on the principles of Hazard Analysis and Critical Control Points (HACCP) [4]. In the EU the HACCP system is laid down in Directive 94/43/EEC on the hygiene of foodstuffs [5].

HACCP is currently the best-recognized management tool that links together all safety-related control measures into one single management system [6]. HACCP prerequisites are cleaning and disinfection in purpose to control hazards, especially cross-contamination, and consequently food poisoning outbreaks and harmful contaminants in food.

Cleaning and disinfection, microbiological purity of surfaces in food contact, and microbiological quality of food are unavoidable topics when considering food safety [7].

The aim of this paper is to bring together above mentioned topics and point to the importance of hygienic practices in the production of food that meets official microbiological criteria.

Cleaning and disinfection in the food industry

Good manufacturing practices introduce hygiene rules that reduce contamination by pathogens and microorganisms that spoil food. The guide Basic Principles of Cleaning and Disinfection in Food Production [8] states that hygienic design principles are applied to enable efficient and effective cleaning and disinfection, including sterilization regimes, to reduce or eliminate the risk of cross-contamination.

Accordingly, cleaning and disinfecting as hygiene maintenance procedures are part of the prerequisite GMP/GHP programs for the implementation of the HACCP system in food production plants based on ISO 22000. Namely, during the production process, surfaces are contaminated with various pollutants that can be physical, chemical, and microbiological in nature and include lubricants, grease, chemical and/or food residues, allergens, microorganisms, etc.

According to Fryer et Asteridaou [9], the types of contamination in the food production process are as is presented in Figure 1. Reactive fouling is sediment as a result of the reaction of some components within the food matrix. Biological fouling is the adhesion and accumulation of microorganisms on the surface laying a foundation for the propagation of biofilms. Crystallization or precipitation occurs when the component dissolved in the liquid has reached its maximum solubility limit. Particulate fouling is the adhesion of particles and pollution by corrosion is a consequence of surface corrosion.

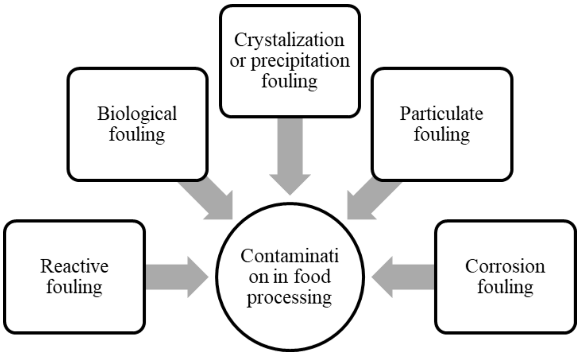

Figure 1. Sources of contamination in food processing [9]

The combination of the above-mentioned methods of soiling makes it difficult to achieve the desired cleaning effects.

Physical cleanliness means that there is no visible waste, foreign matter, or slime on the equipment's surface. Chemically clean surfaces are surfaces from which undesirable chemical residues have been removed, whereas microbiologically clean surfaces imply freedom from spoilage microbes and pathogens [10]. After successful cleaning of surfaces, disinfection can be carried out.

Organisms in a food plant can be considered as „transient" (relatively easily removed by cleaning) and resident (more difficult to remove by cleaning) with the latter persisting in food plants for many years even after cleaning [11].

In contrast to sterile surfaces and the complete absence of microorganisms on them, on disinfected surfaces, microorganisms can remain in prescribed and acceptable numbers. Disinfection thus reduces the number of microorganisms to a level that does not threaten the safety and usability of food.

In Appendix 3 of the guide Basic Principles of Cleaning and Disinfection in food production [8] there are guidelines for disinfection procedures (and rinsing if necessary), after cleaning and the monitoring and inspection of cleaning, as follows:

1. disinfect the drain parts (in the recommended concentrations advised by the chemical manufacturer and reassemble the drains),
2. working as a team, apply the disinfectant (in recommended concentrations advised by the chemical supplier) to all exposed surfaces, doing so from top to bottom, including walls and floors; determine whether the disinfectant is in contact with the surfaces for the appropriate contact time,
3. when using disinfection nozzles, choose the correct nozzle for an efficient, effective, and sustainable disinfection process,
4. determine whether all dismantled parts have been thoroughly disinfected,
5. reassemble the equipment and re-disinfect surfaces, after re-assembly,
6. fogging can be used if required,
7. squeegee floor surfaces dry.

In the cleaning of closed processes, pre-rinsing with cold water is carried out to remove loose soil. Drainage, minimization of internal probes, crevices, and stagnant areas, arrangement of valves couplings, and instrument ports, and instrumentation should be planned carefully so that the equipment is easily cleanable. Problems caused by equipment constructions and materials cannot be eliminated with cleaning in places (CIP), because the CIP treatment was not designated to eliminate biofilms [12]
According to EHEDG (2021) [8], the following factors should be considered when choosing a disinfection method, as is presented in Table 1.

Table 1. Factors for choosing a disinfection method

Factors	Request satisfy
Microorganisms to be destroyed (efficiency)	√
The impact of pollution residues on surfaces	√
Contact time	√
The concentration of the product to be applied	√
Type of surfaces to be disinfected	√
Material compatibility	√
The sensitivity of the food production process	√
The toxicity of the disinfectant and the impact on personnel	√
Safety for employees	√
The environment, including wastewater and wastewater treatment	√
Method of application (liquid, spray, aerosol; labelling requirements, etc.)	√
Temperature range of application	√
Stability, shelf life, and their effect of the dilution of the product	√
Water quality (hardness, chlorine level, etc)	√
Profitability	√

A special problem in the food industry is the formation of a biofilm. In the food industry through cleaning and disinfection of surfaces generally prevent biofilm formation. Biofilms form on surfaces that are physically difficult to clean or are such that they are difficult to clean, for example, due to poor hygienic design. Also, biofilms (microorganisms plus associated organic matrix), can be difficult to remove with the organisms inside the biofilm having increased resistance to antimicrobial agents including biocides [13]. Monitoring cleaning programs can therefore involve looking for the presence of microorganisms, organic residues, or both [14].

Bacteria growing in a biofilm are more resistant to many antimicrobial agents, compared to the same bacteria growing and developing in a free-swimming (planktonic) state [15]. In the food industry, biofilms can cause equipment failure, reduce the efficiency of heat exchangers, and reduce the quality of safety of the final product.

Non-oxidizing disinfectants, such as quaternary ammonium compounds (QAC), biguanides, and amphoteric or triamines penetrate the cell wall and disrupt the phospholipid molecules that make up the bacterial cell membrane; they then block the metabolic pathways required for the microorganisms to survive and/or cause vital cell contents to leak out. In any case, the vital functions of the microorganisms cease [16].

Application of biocides in the food industry

Unlike antibiotics, disinfectants do not work on a key-lock principle, in which the active ingredient attacks cell metabolism at very specific locations. The development of biocidal formulations, as a mixture of two or more antimicrobial substances with different modes of action, is an interesting approach to potential biocidal activity at a time of increasing bacterial resistance. According to [17] new disinfectants and formulations must have appropriate characteristics such as:

- activity at low concentrations,
- a wide range of effects,
- that they are cheap,
- that they do not influence the use of the product and organoleptic properties,
- that they are compatible with the surfaces,
- that they are non-toxic or have low toxicity,
- not to endanger the environment.

Common chemical disinfectants used in the food industry can be divided into two groups: oxidizing and non-oxidizing agents. Oxidizing disinfectants such as hypochlorite solutions, peracetic acid, and hydrogen peroxide attack the entire cellular material and stop the functioning of the microorganism.

A study by Mc Donnell and Russell [18] showed that there is a decreasing tolerance to disinfectants (Figure 2). Also, it has been demonstrated that sublethal exposure to biocidal agents can lead to the development of tolerant isolates [19]. For the effective use of disinfectants, it is necessary to follow the information provided by the manufacturer such as concentration, contact time, and application temperature (all based on recognized microbicidal standard tests).

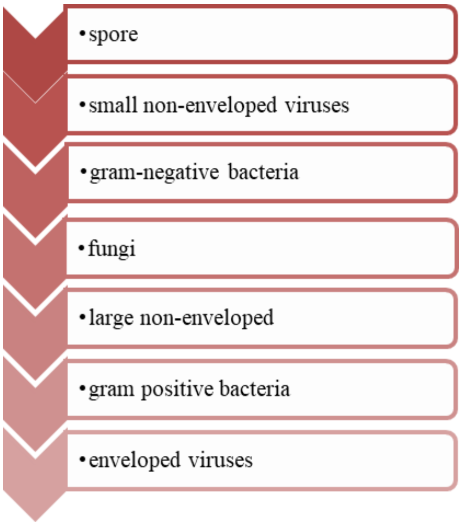

Figure 2. Microbial decreasing tolerance to disinfectants [18]

Disinfectants for food processing plants are used in concentrations far higher than the inhibitory effect. Therefore, microorganisms are destroyed to an acceptable level, if the surface is first sufficiently cleaned, sufficiently drained of the rinse water, and after the manufacturer's instructions are followed. It is important to comply with the recommended exposure time of the disinfection solution on completely wet surfaces. The effect of a certain number of common disinfectants in the food industry, in the recommended contact time of 5 minutes, is shown in Table 2. Ideally, chemical disinfectants should be dispensed automatically via a compatible dispensing unit. There is no scientific evidence that microorganisms develop resistance to biocides, if the disinfectant is used correctly in the required strength, and contact time and correctly applied in accordance with the manufacturer's instructions.

Table 2. Common disinfectants used in the food industry (contact time 5 minutes) [8]

Biocide	The concentration of an active substance
Chlorine	50 – 1000 ppm Active Clorine
Hydrogen peroxide	100-1000 ppm
Peracetic acid	50 – 200 ppm
Iodophor	10 -100 ppm
Quaternary ammonium agents	200-1000 ppm
Alcohol	60 -70%

There are regional differences, but in general, it can be advised that all chemicals should be washed off surfaces after use. Rinsing significantly reduces the level of chemical residues remaining on cleaned and/or disinfected surfaces, and therefore the likelihood that these residues will subsequently enter the food. The reduction is further increased if hot water is used. Rinsing of food contact surfaces after disinfecting/cleaning is a recommended best practice approach to ensure minimization of food contamination, regardless of the composition of the cleaner, disinfectant, or material involved.

Therefore, the potential ingestion of residues resulting from the approved use of these types of products does not represent a significant health hazard under the intended conditions. Codex Alimentarius – Section 5.1.2 –Cleaning and disinfection methods and procedures [20] states that disinfection must be followed by rinsing unless the manufacturer's instructions (on the product label) indicate on a scientific basis that rinsing is not necessary. Some countries have legal requirements for the registration of a disinfectant and must state this on their label (eg. EU). In the UK, rinsing is not routinely carried out in the production of ready-to-eat food products. Namely, the balance of residue absorption in food products is considered to be less risk of adding water to surfaces during rinsing (which may contain microorganisms) and the associated additional time for food processing equipment to dry completely. In such circumstances, disinfectants are also tested to assess the likelihood that residual disinfectant on surfaces will cause organoleptic changes in food products processed on the line.

Li et al. [21] investigate the effect of food residues (milk, beef gravy and tuna gravy) on the bactericidal efficiency of benzalkonium chloride (BAC) and alkyldiaminoethylgycine hydrochloride (AGH). The results indicate that applying a proper washing process prior to disinfectant treatment can prevent cross-contamination.

The advantages and disadvantages of some disinfectants according to [22] are presented in Table 3. Peracetic acid (PAA) has attracted growing attention as an alternative oxidant and disinfectant in wastewater treatment due to the increased demand to reduce chlorine usage and control disinfection byproducts [23]. Hydrogen peroxide is extensively used as a biocide, particularly in applications where its decomposition into non-toxic by-products is important [24]. Chlorine in molecular and in compound forms is known to pose many health hazards. Hypochlorite addition to soil can increase chlorine/chloride concentration, which can be fatal to plant species if exposed [25]. Quaternary ammonium salts have a broad spectrum of biological activity, showing among others, the following effects: algistatic, bacteriostatic, tuberculostatic, sporostatic, and fungistatic. Their activity against viruses is also known [26].

Ethanol and povidone-iodine are important microbicides that inactivate bacteria and viruses [27].

Table 3. Advantages and disadvantages of some disinfectants [22]

Biocide	Advantages	Disadvantages
Alcohols	effective against vegetative cells, non-toxic, easy-to-use, colourless, harmless on the skin, soluble in water, volatile	microbiostatic, ineffective against spores.
Peracetic acid	effective in low concentration, broad microbial spectrum, kills spores, penetrates biofilms, non-toxic	corrosive, unstable.
Hydrogen peroxide	decomposes to water and oxygen, is relatively non-toxic, easy to use, weakens biofilms, and supports detachment.	High concentrations need, corrosive.
Chlorine	effective in low concentrations, broad microbial spectrum, easy to use, supports microbial detachment, cheap.	Toxic by-products, resistance development residues, corrosive, reacts with EPS, discolouration, explosive gas
Hypochlorite	cheap, effective in a broad microbial spectrum, easy to use, and supports detachment.	Unstable, toxic, oxidative, corrosive, rapid regrowth, no prevention of adhesion, discolouration of products.
Quaternary ammonium agents	non-toxic, prevent regrowth, supports microbial detachment, and are non-irritating, non-corrosive, odourless, and flavourless.	inactivated in low ph and by salts (Ca^{2+} and Mg^{2+}), resistance development, ineffective against Gram-negative bacteria.
Iodophor	non-corrosive, easy to use, non-irritating, broad activity spectrum.	expensive, flavour, odour, and form purple compounds with starch.

According to the standard tests EN 1276 [28] available a reduction of 5 log units is needed for the agent to be effective against bacterial cells and a 4 log reduction for the yeasts and moulds according to EN 1650 [29].

Microbiological analysis of surface samples

Several scientific studies have documented the problems associated with unsatisfactory hygiene of food contact surfaces, indicating that they not only reduce the shelf life of products but also increase the risk of foodborne illness due to the presence of pathogens [30, 31, 32]. Performing a microbiological analysis is necessary to check the microbiological purity of surfaces that come into contact with food. The microbiological criteria for aerobic mesophilic bacteria and *Enterobacteriaceae* are usually applied and results are expressed as CFU/cm^2 (Vodič Srbija, Vodič BH). [33,34]

Surface sampling is a very important part of monitoring the hygienic condition of the process production. International standard ISO 18593 [35] specifies horizontal methods for sampling techniques using sick swabs, contact plates, sponges, and clots on surfaces in a food-producing environment. Obtained samples are further analyzed to detect or enumerate culturable microorganisms such as pathogenic or non-pathogenic bacteria yeasts and moulds [36]. Contact plates, sponges, and swabs are most often used for sampling from surfaces. There are advantages and disadvantages to each of these surface sampling methods. Swab and sponge sampling methods are simple and do not require complicated training of the sampler. The common characteristics of swab and sponge methods are:

- require commercial sterile sampling material,
- can be used to sample small and large areas
- after sampling can be made further dilutions.

The disadvantage of these methods, especially when it is necessary to report the number of microorganisms, is the material used for sampling. Namely, the swab's head or sponge retains a certain number of sampled microorganisms. Cotton swabs have traditionally been recommended for microbial surface sampling, but there are several other swab materials to choose from, as well as various forms of the swab's head. The influence of the swab on the results of analysis has been discussed in many studies [37,38]. The conclusion regarding swab material is contradictory and this emphasizes the importance of evaluating the specific swabs for the intended use prior to application [39]. However, sponges if returned to an enrichment medium for pathogen detection offer superior sensitivity [40].

The contact plates method is also easy to apply and is often used for flat surfaces in industrial plants. With the method of contact plates, the microorganisms from the sampled surface are retained as an imprint. It is applicable only to small areas, and a large number of microorganisms per unit area leads to innumerable overgrowth of colonies [41]. Apart from those described above, other, less common, methods are also applied, such as ATP-bioluminescence, protein detection method, staining in combination with microscopy, and image analysis.

The level of confidence in the results obtained after sampling from surfaces, both for those from the field and in controlled laboratory studies, is difficult to determine due to the large number of variations that affect sampling performance [42,43]. More recently there have been many reports of sampling effects depending on the sampling tools used. Lutz et al. [44] evaluate the performance of four sampling methods (contact, plates, electrostatic wipes (wipe), swabs, and a novel roller sampler) for recovery of *Staphylococcus aureus* from stainless steel surfaces. The study demonstrates that the selection of the sampling method must be carefully considered, given that different methods have varying performances.

Artificial contamination of surfaces in laboratory conditions could not provide real environmental conditions. However, performed experiments showed a difference in the enumeration of *Escherichia coli* with two different methods after surface swabbing and recovery was less than 50% for each of them [45]. Grosselin et Leblanc

[46] show that the different microorganisms are not recovered the same because they are probably less resistant to desiccation. Also obtained results showed no influence of surface type sampled in the recovery rates [46], which is interesting because different surfaces as different as plastic (passive surface), glass (charged surface), and stainless steel (charged surface) may have different microorganisms attachment [47,48, 49].

Microbiological results from surfaces that come into contact with food should be considered with special care, especially considering that the ISO 18593 [35] standard states that it is not applicable for the validation of cleaning and disinfection procedures.

Microbiological food criteria

Microorganisms present in food can change the quality of food to an unacceptable organoleptic level, or endanger the health of consumers due to the presence of pathogenic microorganisms or their toxins. Contaminated ready-to-use food can be non-processed or previously processed. Various techniques are used to extend the shelf life and to reduce the number of microorganisms present in food [50, 51].

Salmonella spp, *Listeria monocytogenes*, and *Escherichia coli* O157:H7 are considered among the most important pathogens [52,53,] and also special attention has to be paid to microorganisms resistant to antibiotics [54]. Due to the low infectious dose, food poisoning can cause pathogens whose presence in food cannot be recognized organoleptically, nor does the food have visible spoilage loops. Therefore, reliable microbiological tests ([55,56] and official microbiological criteria are needed, even in cases when added culture is present as a quality characteristic of foodstuff [57-59]. Microbial criteria provide information on which microorganisms should be tested in food, a sampling plan, and reference values.

The microbiological criteria of many non-EU members originate from the European Union (EU) legislation as the harmonization of regulations to facilitate food trade between countries. Namely, the European Commission (EC) harmonized microbiological criteria with the Regulation on microbiological criteria for food [60] , which entered into force in January 2006, and the General Food Law [61], which entered into force in February 2002, although certain key provisions have only been applied since January 2005. In addition, there is a separate regulation establishing special rules for food of animal origin [62].

Two types of microbiological criteria are listed in Regulation (EC) nl 2073/2005 [60], including criteria for pathogenic microorganisms and indicator organisms:

- food safety criterion – determines the acceptability of the product or series (lot); refers to food placed on the market until its expiration date,
- process hygiene criteria – determine the acceptability of the process; they are applied only during the production process.

When the food safety criteria are not met, the food is a source of health-threatening microorganisms and must be withdrawn from the market. In the event of unsatisfactory results as regards process hygiene criteria, it is necessary to initiate corrective action and monitor its effectiveness.

The sampling plan can be:

- two classes, based on which the analyzed samples can be classified into two categories: satisfactory and unsatisfactory, based on the unequivocal value m=M; this plan is absolute, and the sample units can „pass“ or „fail“, which directly affects the status of the sample, e.e. the lot,
- three classes, based on which the analyzed samples are divided into three categories: satisfactory, acceptable, and unsatisfactory; in this case, the defined number of sample units is allowed to exceed the lower limit (m), but not the upper limit (M).

Therefore, if a two-class sampling plan is applied, the analyzed samples can be classified into two categories:

- satisfactory
- unsatisfactory.

If a three-class sampling plan is applied, the analyzed samples can be classified into three categories: satisfactory – all tested units have a value less than m,

- acceptable – there are less than or equal to c tested units that have values between m and M,
- unsatisfactory – if more than c units have a value between m and M, or if at least one unit has a value greater than M.

For each sampling plan, there is a certain probability of acceptance of a particular lot of products. ICMSF [63] provides an illustrative explanation of the two classes of the sampling plan, based on the event distribution of *Salmonella* spp. in one lot. If salmonella was not detected by the microbiological examination of 5 sample units, the probability that salmonella was present in the lot is as follows (Table 4):

- 90% probability that the accepted lot contains 2% *Salmonella*-positive units,
- 77% probability that the accepted lot contains 5% Salmonella-positive units,
- 59% probability that the accepted lot contains 10% *Salmonella-positive* units,
- 17% probability that the accepted lot contains 20% *Salmonella-positive* units,
- 3% is the probability that the accepted lot contains 30% *Salmonella-positive* units,
- 1% is the probability that the accepted lot contains 50% *Salmonella*-positive units.

Table 4. Acceptance probability (two-class sampling plan) according to Cole [64]

Lot composition		Probability of Acceptance for Two Class Sampling Plan (c=0) (%)				
% acceptable	% not acceptable	5 sample units	10 sample units	20 sample units	60 sample units	100 sample units
98	2	90	82	67	30	13
95	5	77	60	36	5	1
90	10	59	35	12	<	<
80	20	17	11	1		
70	30	3	03	<		
50	50	1	<			

Risk-based sampling plan according to International Commission on Microbiological Specification for Foods (ICMSF) [63] is a 3x5 matrix, consisting of the probability of danger vs. levels of hazard (Figure 3).

Degree of Concern Relative to Utility and Health Hazards	Conditions for handling and consuming food		
	Reduced hazard	No change in hazard	May increase hazard
There is no direct health hazard (ie common contamination, reduced product shelf life, product spoilage)	Case 1 3 classes, n=5, c=3	Case 2 3 classes, n=5, c=2	Case 3 3 classes, n=5, c=1
Health hazard - Low, indirect (i.e. indicator organisms)	Case 4 3 classes, n=5, c=3	Case 5 3 classes, n=5, c=2	Case 6 3 classes, n=5, c=1
Health hazard - Moderate, direct, limited spread	Case 7 3 classes, n=5, c=2	Case 8 3 classes, n=5, c=1	Case 9 3 classes, n=10, c=1
Health hazard - Moderate, direct, potentially extensively spread	Case 10 2 classes, n=5, c=0	Case 11 2 classes, n=10, c=0	Case 12 2 classes, n=20, c=0
Health hazard - Severe, direct	Case 13 2 classes, n=15, c=0	Case 14 2 classes n=30, c=0	Case 15 2 classes, n=60, c=0

Figure 3. Risk-based sampling plan according to ICMSF [60]

The probability of danger in the conditions of handling and consumption of food has three levels:

1. reduced degree of danger
2. there is no change in the degree of danger,
3. the danger may increase.

The five levels of hazard contain deviations of health hazards and four levels of graded hazard. So extreme cases are represented by:

- Case 1: there is no danger to health, i.e. common contamination that can reduce product shelf life and cause product spoilage, and food handling and consumption conditions reduce the degree of danger; the sampling plan is three classes, n=5, and c=3,
- Case 15: the danger to health is great and direct, and the conditions of handling and consumption of food can increase the danger; the sampling plan is 2 classes, n=60, and c=0.

Efficient monitoring of the quality of the foodstuff at different steps of the process is important to avoid foodborne infections and even epidemics that may cause morbidity and mortality in large numbers of consumers within a short period of time [65]. According to Lee et al. [66] in order to accurately represent the population, a sampling plan should consider the sample size, the sampling points, the frequency of sampling, and the distribution of sample components. Monitoring of microbiological quality of foodstuffs can provide essential information related to the prevention of foodborne disease) [67].

Conclusions

During food production, there is a risk of microbial cross-contamination between raw products and food contact surfaces, food handles, and ready-to-eat foods. Good hygienic practices with effective cleaning and disinfection have to ensure the required microbiological purity of food contact surfaces as well as food safety.

Surface sampling is a very important part of hygienic condition monitoring in-process production. Also, this is some kind of preventive in assuring food quality and protection of consumers. Besides regular checking the methods for surface sampling often have a place in the finding of a source of food born outbreaks.

Microbiological criteria establish acceptable levels of microorganisms in foods. Correctly implemented cleaning and disinfection in production facilities have a key influence on meeting the microbiological criteria of food.

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UTICAJ ČIŠĆENJA I DEZINFEKCIJE U PROIZVODNIM POGONIMA NA MIKROBIOLOŠKI KVALITET HRANE

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Sažetak: *Dobra higijenska praksa smanjuje mogućnost kontaminacije hrane patogenim mikroorganizmima i mikroorganizmima koji kvare hranu. Tokom proizvodnog procesa dolazi do onečišćenja površina različitim zagađivačima koji mogu biti fizičke, hemijske i mikrobiološke prirode. Mikroorganizmi predstavljaju poseban problem jer se u pogodnim uslovima razmnožavaju i stvaraju metabolite kojima ugrožavaju zdravstvenu bezbjednost hrane i/ili narušavaju kvalitet hrane.*

Poseban problem u prehrambenoj industriji je formiranje biofilma, koji predstavlja zajednicu mikroorganizama koji rastu i razvijaju se ugrađeni u samoproizveden matriks ekstrapolimernih supstanci. U slučaju proizvodnih procesa za koje je svojstveno ili moguće stvaranje biofilma, temeljno čišćenje i dezinfekcija površina su prventiva stvaranju biofilma. Efektivnost primjene procedura dobre higijenske prakse odražava se na mikrobiološki kvalitet površina koje dolaze u kontakt sa hranom i mikrobiološki kvalitet hrane. Mikrobiološki kvalitet površina koje dolaze u kontakt sa hranom obično se procjenjuje preko ukupnog broja mikroorganizma i/ili detekcije prisustva patogenih ili uslovno patogenih mikroorganizama. Za hranu se primjenjuju dvije vrste mikrobioloških kriterijuma hrane, uključujući kriterijume za patogene mikroorganizme i indikatorske organizme. Kriterijum bezbjednosti hrane određuje prihvatljivost proizvoda ili serije (lota) i odnosi se na hranu stavljenu na tržište sve do isteka njenog roka upotrebe. Kriterijumi higijene procesa proizvodnje određuju prihvatljivost procesa i primenjuju se tokom proizvodnog procesa. Pojedinačni mikroorganizmi, grupe mikroorganizama ili njihovi toksini koji se ispituju, plan uzorkovanja i mikrobiološki kriterijumi definisani su u okviru nacionalih i internacionalnih propisa. Kada nisu zadovoljeni kriterijumi bezbjednosti, hrana je izvor po zdravlje opasnih mikroorganizama i mora biti povučena sa tržišta. U slučaju kada nisu zadovoljeni kriterijumi higijene proizvodnje, potrebno je pokretanje korektivne mere i praćenje njene efektivnosti. Iako postoje različiti putevi i izvori kontaminacije hrane, provođenje sanitarnih procedura u objektima za proizvodnju, rukovanje i distribuciju hrane, neophodan je doprinos zdravstvenoj bezbjednosti hrane i očuvanju kvaliteta hrane.

Ključne riječi*: čišćenje, dezinfekcija, hrana, mikrobiološki kvalitet*