MICROBIOLOGICAL HAZARDS IN MASS CATERING AREAS ON SELECTED EXAMPLES

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Abstract

Mass catering establishments involve a number of threats related to the health safety of the food produced there. The most important microbiological threats include: viruses, prions, bacteria, moulds as well as their toxins and parasites. Those biological hazards pose a hazard for people occupied in the food production process and also for consumers. The required microbiological quality of meals served in catering facilities is very important given the risk of potential collective food poisoning. The aim of the article is to assess the microbiological cleanliness of surfaces, staff hands and technological equipment used in food production, taking into account selected microclimate parameters. Three mass catering establishments were studied, one open and two closed. Microbiological purity tests of surfaces intended for food production were carried out using the 3M™ Clean Trace™ NGi luminometer and the compact AXIOMET AX-DT100 microclimate recorder, equipped with an accurate air temperature and humidity sensor. The obtained research results were then compared with reference values and a plan was proposed to improve hygienic conditions in the catering establishments in question. A review of the results of studies carried out on microbiological cleanliness in selected mass catering establishments showed acceptable exceedances of the reference contamination limits.

Keywords: microbiological threats in food, mass catering of the population, measurements of microbiological pollutants

1. Introduction

The health and longevity of a person mainly depends on genetic predispositions and physical activity, as well as the quality of the food they consume. Properly balanced and healthy nutrition has an impact on the development of the body, the maintenance of physical and mental fitness, and the effective treatment of certain diseases. The food consumed by humans should not only be tasty and visually appetising, but above all wholesome and safe for health. Microbiological hazards

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in food-bacteria, microscopic fungi (yeasts, moulds), parasites, substances of plant and animal origin are the most common causes of illness (Kołożyn-Krajewska, 2019). Contamination of semi-finished products, products or finished meals with pathogens leads to food poisoning, which can range from mild to very acute and chronic forms threatening both health and life.

According to the Regulation of the Minister of Health of 11 December 2020 (Polish Journal of Laws/Dz.U. of 14 December 2020, item 2234) "harmful biological agents include cellular microorganisms, internal parasites, non-cellular entities capable of replication or transfer of genetic material, including genetically modified cell cultures that may cause infection, allergy or poisoning".

There are four groups of biological agents, depending on their ability to cause infection, their ability to spread to humans and the prophylaxis used:

Group 1 – biological agents that pose little risk to humans. This group includes bacteria used in the production of antibiotics, vitamins, which are involved in the natural processes of ensiling, production of cheese, kefir, yoghurt and some moulds of the genus *Aspergillus* or *Penicillium* (Zapór and Kowalska, 2010). As regards work involving agents belonging to group 1, the general principles of occupational health and safety should be observed in accordance with the regulations in force in this area.

Group 2 – biological agents that may cause disease in humans and present a danger to workers, but are unlikely to spread. Mostly effective prevention and treatment methods exist for them.

Group 3 – biological agents that can pose a high risk to humans and are very likely to spread in the human population. Effective methods of prevention and forms of treatment are usually available for them.

Group 4 – biological agents that pose the most serious risk to health and life. They spread easily among the human population and cause a serious course of disease and can lead to death. There are no effective prevention and treatment methods against them (Polish Official Journal/Dz.U. of 14 December 2020, item 2234).

Microbiological hazards in food can be divided into harm caused by saprophytic and pathogenic organisms. Food production involves the growth of microorganisms at each stage of processing up to the finished product. Therefore, the quality of the finished product, its nutritional, sensory and shelf-life properties will depend on the number of microorganisms. Saprophytic organisms (e.g. Pseudomonas, Penicillium), which multiply at high levels in food, cause deterioration in the taste, smell, texture and consistency of the food, contributing to the spoilage of products and thus affecting the health of consumers.

From an epidemiological point of view, pathogenic bacteria such as *Salmonella* spp., *Campylobacter* spp., *Listeria* spp., *Yersinia spp.* or toxic strains of *Escherichia* coli pose the greatest risk. *Salmonella* sp., like *Campylobacter* sp., can be found in meat and poultry products, milk, especially unpasteurised milk and eggs. In contrast, *Listeria monocytogenes* contaminates dairy products mainly by multiplying in blue and smeary cheeses, raw pork and poultry meat, pasteurised milk, unwashed fruit and vegetables (Kołożyn-Krajewska 2014). Further danger is posed to consumers by metabolites of bacteria, including botulinum toxin (botulism), which produces survival forms and multiplies under anaerobic conditions. The most common route of botulism is the consumption of products that contain botulinum toxin (tinned meat, fish and vegetables).

Viruses as well as microscopic fungi (yeast and moulds) also pose a major risk. Viruses of animal origin mainly originating from pigs and cattle can infect humans, which can lead to the risk of pandemics. These viruses are transmitted by milk, soft fruits, mussels and oysters. Most viruses are killed in the pasteurisation process; however, the hepatitis A virus, which is resistant to this process, remains a significant hazard (Kołożyn-Krajewska, 2019, Berthold, Żukowska, 2008).

Another group of microorganisms are moulds that contribute to the spoilage of foodstuffs with a characteristic musty odour perceptible even after heat treatment (Czarniecka-Skubina, 2016). The most common genus of moulds include: *Mucor, Cladosporium* growing black mycelium on food products, while a fungus of the genus *Penicillium* forms green coloured mycelium. Moulds produce mycotoxins that are very dangerous to health of living organisms. Particularly dangerous are aflatoxins from carcinogenic moulds growing on food (Zapór and Gołofit-Szymczak, 2009).

One of the most important factors for the safety and quality of the food produced is assuring adequate hygiene in all production areas. In order to function properly, they must have appropriately designed and equipped premises and employ qualified personnel. To this end, priority is also given to the creation of appropriate microclimatic conditions in food production areas, ensuring cleanliness and tidiness of the processing line and the personal hygiene of employees in order to eliminate humans as potential vectors of pathogens. The aim of the article is to assess the microbiological cleanliness of surfaces, staff hands and technological equipment used in food production, taking into account selected microclimate parameters.

2. Materials and methods

This article is devoted to the assessment of microbiological cleanliness of surfaces, personnel hands and process equipment used during food production, taking into account selected microclimate parameters. The assessment was carried out in three mass catering establishments, two of the closed type, and namely: The Food Department of the Fire University – 400 people served, the canteen of an Elementary School – 1200 people served, and an open-type establishment – 120 people served. Tests were carried out between May and July 2022 in triplicate from four working surfaces (workstations) during the production and serving of meals and the hands of employees:

1. raw meat processing station
2. vegetable preparation station
3. workplace for serving of finished dishes
4. clean tableware rack station.

The 3M™ Clean Trace™ NGi luminometer (Figure 1), a portable, lightweight device with a LCD display, was used to measure the level of microbial contamination from work surfaces. The luminometer, along with a set of 3M reagents, is used to quickly and effectively measure contamination on work surfaces. The research uses adenosine-5-triphosphate (ATP) bioluminescence technology as an indicator of the number of microorganisms or organic residues in the sample under study. ATP is a nucleotide present in every living cell and in materials of biological origin. It is measured using an enzymatic reaction of so-called luciferin (found in nature in tails of glow-worms), the so-called Luciferasa and ATP. The reaction results in a luminous intensity proportional to the ATP content. The intensity of light measured with a luminometer is expressed in Relative Light Units (RLUs) (Griffith 2016, Tomczyk et al., 2014). With this method, it is possible to effectively monitor the sanitary and hygienic condition of production surfaces, the hands of production staff and properly performed cleaning and disinfection processes of premises, equipment and the skin of employees (Bany 2023). A low ATP value during the measurement indicates that the surface is free of organic and microbial contamination, while a high ATP value means that the surface has been contaminated with organic substances and microorganisms.

Figure 1. 3M™ Clean Trace™ NGi luminometer and 3M™ swabs for sampling

The tests were carried out in accordance with EN ISO 18593:2018-08 Microbiology of the food chain – Horizontal surface sampling methods. All the work surfaces from which swabs have been taken were made of food-grade stainless steel. In addition, following the swabbing of the production surface, a swab was also taken from the hands of the person performing the given work at the particular workstation. The study consisted of taking swabs of production surfaces and hand skin surfaces four times. Only two persons used protective gloves. Three swabs were taken during production operations before washing and disinfecting operations, the fourth one after washing and disinfecting hands and work surfaces according to the current hygiene plan. The professional cleaning and disinfecting agents included in the hygiene plan for washing and disinfecting work surfaces and hand skin were used for decontamination (Table 1).

Table 1. List of preparations for cleaning and disinfection in mass catering facilities

Mass catering unit	**Washing and disinfection**	
	Surfaces	**Hands**
Open-type establishment	H621 VOIGT	washing – Ecolab Manisoft disinfection – Skinman Soft – Ecolab
Elementary School	washing – Dezopol-med (VOIGT) disinfection – DR MANUSTERIL (DRACO)	washing – H614 (VOIGT) disinfection – DR MANUSTERIL (DRACO)
Fire University	washing – Neoform K plus (DR. WEIGERT) disinfection – Neoform K sprint (DR. WEIGERT)	washing – triformin HR (DR. WEIGERT) disinfection – DR MANUSTERIL (DRACO)

Disposable swabs inside each test tube were used to collect the swabs. Swabs were taken from a working surface of approximately 25 cm². Furthermore, swabs from the workers' hands were taken from the area between the fingers, the inside of the hand and the peri-nail area (Fig. 2). After removing the dedicated swab from the test tube and rubbing the end of the swab against the surface to be tested, it was placed back into the sample, which was inserted into the detection chamber of the instrument. After 15 seconds, the LCD display showed the result of the measurement in RLUs.

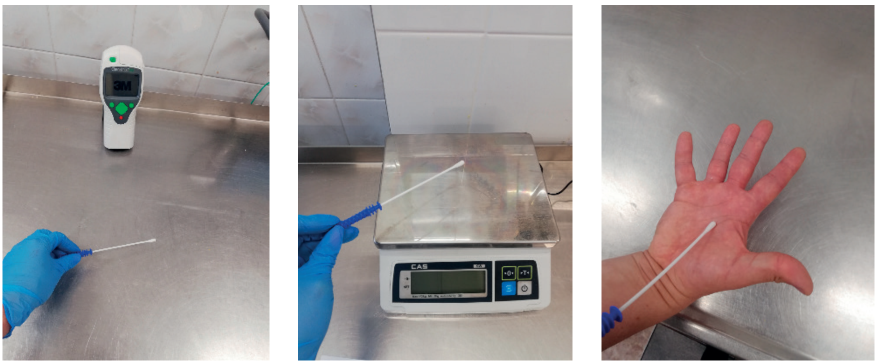

Figure 2. Collection of biological material from work surfaces and workers' hands

An indispensable measurement in determining microbiological purity is the recording of temperature and humidity (Isańska-Ćwiek, 2006). For this purpose, the compact, lightweight and portable AX-DT100 recorder was used (Fig. 3).

Figure 3. AX-DT100 logger for temperature and humidity measurements

The measured values of air temperature and humidity in a hot kitchen for all catering establishments are shown in Table 2.

Table 2. Air temperature and humidity values measured on the day of sampling

Place of measurement	Measurement date	Air temperature Ta [°C]	Air humidity RH [%]
Open-type establishment	03.05.22	22.8	57.2
Elementary School	08.05.22	31.3	96.2
University	10.07.22	26.7	66.6

3. Results and Discussion

The averaged results of the conducted measurements of microbiological cleanliness of surfaces and technological equipment, as well as of the hands of employees at selected positions in the analysed mass catering establishments, are presented for clarity in a tabular overview (Table 3).

Table 3. Percentage difference in averaged RLU values before and after cleaning and disinfection treatments

Place of measurement	Station number	Working area		Hands	
		Average RLU value before disinfection	Value of RLU after disinfection	Average RLU value before disinfection	Value of RLU after disinfection
Open-type establishment	1	845	29	594.33	13
	2	133	11	107.33	15
	3	61.5	18	67	16
	4	70.33	32	29	15
mean		277.46	22.5	199.41	14.75
percentage difference		**91.89%**		**92.6%**	

Place of measurement	Station number	Working area		Hands	
		Average RLU value before disinfection	Value of RLU after disinfection	Average RLU value before disinfection	Value of RLU after disinfection
Elementary School	1	952	53	689	19
	2	205.33	13	117.33	42
	3	73.33	11	58.67	21
	4	73	29	34.33	18
mean		325.91	26.5	224.83	25
percentage difference		**91.87%**		**88.88%**	
University	1	798.67	32	652.33	15
	2	110	16	119.67	25
	3	64	15	59	19
	4	58.66	21	27	16
mean		257.83	21	214.5	18.75
percentage difference		**91.86%**		**91.26%**	

On the basis of conducted tests and a comparison of the averaged values of the results obtained, high RLU values were observed at position No. 1 in relation to positions No. 2, 3 and 4 in all the mass catering establishments analysed.

The high RLU values at the raw meat processing station are mainly attributable to contamination of working surfaces and hands by substances of organic and microbiological origin present in the blood serum, as well as by contamination caused by inadequate storage and transport. Contamination levels also tend to increase due to conditions of the working environment, such as air temperature and high humidity, as well as if the surface is left dirty and wet over a long time (Prędecka et al., 2022). The results obtained at station no. 1 are similar to those of the measurements carried out in December 2020 at the University. The presented comparison shows that the average values of RLU levels significantly exceeded the acceptable limits of the reference values (Worsfold and Griffith, 1996). The reference values are as follows: for flat and smooth surfaces (e.g. glass or metal) the limit value is 200 RLU, while for plastic, rough surfaces they should not exceed 500 RLU. For sterile areas, the value of 20/50 RLU should not be exceeded.

The highest RLU values were recorded at the Elementary School, where over 1200 pupils are being served. This translates into an increased area of contamination during pre-treatment due to the large volumes of product. Lower RLU values, on the other hand, were recorded at the Open-type establishment and the University. Most pathogens become inactivated at high temperatures during heat treatment performed for a sufficiently long time. To minimise the risk, the temperature of the heat treatment should be controlled and should not be less than

70°C inside the product. Relatively high RLU values were also obtained when hand skin contamination was measured during raw meat handling, which increases the risk of microbial transmission from raw food to ready-to-eat food or to the clean area. Lower RLU values were measured when swabs were taken at the ready-to-eat stations and the pass-through racks where clean (scalded) tableware is stored. These workstations belong to the clean zone and the result shows that the surfaces tested were safe and free of hazardous contamination (Bany, 2023).

Comparing the values of samples obtained at each station, it can be observed that the contamination levels decreased significantly following the cleaning and disinfection procedures. These were carried out in accordance with the facility's hygiene plan, after three swabs at each workstation and hand swabs performed beforehand. The reduction in the level of RLUs at the workstations decreased by more than 90%, as did the level of RLUs in the swab from the skin surface, which was 88.88% only at the Elementary School (Table 3). Nevertheless, after analysing the measurements, it is possible to see increased RLU values after the cleaning and disinfection treatments at two stations (RLU value 53 – station 1, RLU value 42 – station 2). The reasons for these increased values could be caused by improperly performed hygiene procedures, inadequate rinsing of the cleaned surface or insufficient concentrations of cleaning and disinfecting agents. Parameters concerning the concentration of the preparation and its duration of action determine significantly the effectiveness of the disinfection procedures. Controlling the residues of cleaning and disinfecting agents on production surfaces is crucial to ensuring product health safety (Bany, 2023).

During the research it was also observed that production workers used disposable gloves while working. In the case of two individuals, they were observed to wash their hands with the gloves they had previously worked with after performing a particular production activity. To this end, a swab was taken from the surface of the glove to measure the RLU value and compare the results to washing and disinfecting the skin of the hands without gloves. After the measurement, the result reading was found to be over 1200 RLU.

The analysis of microbiological cleanliness was carried out during the normal operation of the establishments, with the full number of customers present. This shows that with a higher number of people using this form of catering, the level of contamination is higher than in establishments where the number of consumers is lower or the meals are served in rotation, i.e. according to the orders placed. This stems from the larger number of products to be handled at the same time while maintaining the required sanitary and hygienic standards. In the case of a plant where more than a thousand people have their meals, over a period of time, the volume of raw materials used in production causes an increased soiling of the work surface and requires more staff to maintain adequate hygiene standards. The process of cleaning and disinfecting the surfaces was carried out correctly and the agents used (Table 1) were found to be effective, as has been confirmed by the measurements taken. Particularly important were the tests on surfaces commonly considered to be "clean", i.e. the area of counters where ready-made dishes are served and the pass-through racks for clean tableware. Maintaining low RLU values at these workstations is extremely important to ensure food safety of the finished product that reaches the consumer. These surfaces must be exceptionally protected from potential contamination by a biological agent that could be carried on the worker's hands or production clothing. For this reason, people working in the pre-treatment area should not move onto the clean area without changing clothes and vice versa. It is important to raise awareness among food production workers of microbiological hazards, including the ways in which they can be transmitted and the diseases they can cause (Bany, 2023).

Measurements of air temperature and humidity taken during food preparation (Table 2) show that in two cases, i.e. at the Elementary School and the University, they exceed the permissible standards (Standard PN-EN 27243 Hot environments. Determination of thermal load acting on humans during work, based on WBGT index). Ambient temperature of 26.7°C with a humidity of 66.6% (University) and a temperature of 31.3°C with a humidity of 96.2% (Elementary School) seem to have a highly adverse impact on the sensation of thermal comfort during work. Furthermore, these parameters determine the heat exchange of the human body with the environment and are responsible for maintaining thermal balance. High humidity also contributes to faster bacterial proliferation on damp surfaces and increases the risk of pathogen transfer from the dirty to the clean zone. What is more, it favours the formation of moulds whose are responsible for the development of cancerous diseases, among other things. The most optimal microclimate conditions for workers were discovered at the Open-type establishment, where the temperature measured during the heat treatment of prepared food was 22.8°C and humidity was 57.2% (Bany, 2023).

A review of the results of studies carried out on microbiological cleanliness in selected mass catering establishments showed acceptable exceedances of the reference contamination limits. These contaminants also affected the skin surface of the hands, which increases the risk of transferring harmful biological agents to the finished product or to the clean area. At the time of the survey, at none of the establishments surveyed was a division observed in the hygiene plan between pre-treatment stations and stations with ready-to-eat food.

4. Summary and recommendations

By assessing the microbiological cleanliness of surfaces and equipment in selected mass catering establishments, it was revealed at which stage of food production the risk tends to be the greatest and whether hygiene measures are applied correctly. These undertakings are crucial to ensure the health safety of the food produced. An analysis of the results of measurements carried out indicated high RLU values at raw meat processing stations in three mass catering establishments.

The processing of food of animal origin is associated with an increased risk to human health and life. The incidence of microbiological hazards in raw meat is higher than in any other types of food. Therefore, especially on these positions, all sanitary recommendations must be observed during the entire food production process, i.e. from pre-treatment to the correct thermal treatment, especially in the case of poultry meat.

The multidirectionality of technological processes is an important stage in food production and requires assuring appropriate ventilation and air-conditioning system. The safety of food preparation and comfort of work are adversely affected by microclimate factors, which, especially in the Elementary School, were found to have been significantly exceeded. In order to ensure proper air exchange, including, among other things, appropriate temperature and humidity, diverse measures should be adopted to modernise the existing ventilation system.

In order to minimise the risk of harmful microbiological agents coming into contact with the ready food, it is essential to comply with the rules laid down in the production safety regulations set out in the Food and Nutrition Safety Act. The most important of these are as follows:

- Providing periodic training on the principles of occupational health and safety and on diseases caused by harmful biological agents.
- Special care during the initial processing of raw materials owing to the possibility of microbiological contamination.
- Activities in the "dirty" area should be carried out using equipment, utensils and devices dedicated only to this area (e.g. suitable cutting boards, knives).
- All prepared raw materials and semi-finished products should be stored and protected in the appropriate manner, with particular attention to hygiene-related aspects, temperature and humidity, so as to prevent the development of microbial flora.
- The use of disposable protective gloves should be limited only to production processes that require them and for skin protection in the case of wounds or other minor injuries requiring hand and food protection. It is also reasonable to use them during the initial (dirty) handling of meat or vegetables and when carrying out cleaning operations.
- Microbiological purity in production processes should be monitored using the bioluminescence method.
- Development of required cleanliness values for the workplaces in question on the basis of the swabs carried out and their inclusion in the hygiene plan especially for high-risk workplaces.

Microclimatic conditions in food production and storage facilities also have an impact on ensuring food safety. Poorly functioning ventilation and air-conditioning system promotes secondary contamination of products and adversely affects the preservation of proper hygiene. To this end, measures should be taken to modernise the ventilation system:

– Hot kitchen premises with high heat and moisture gains should be equipped with a new supply air handling unit to adjust the exhaust air velocity of the kitchen hoods.
– New systems should be equipped with manual temperature controllers.
– The installed air handling units should consist of a heater, a cooling section, a supply fan section, a filter section and automatic control systems. Such a ventilation system would allow automatic reaching of the optimum temperature, polluted air to be removed from the entire room and fresh air to be introduced.

The same technical solutions should be implemented in the rooms of the proper kitchen in the Nutrition Department at the University and in the Elementary School, i.e. where the microclimate conditions were found to be particularly unfavourable.

The adopted solutions will have a direct impact on changing air parameters, eliminating excess humidity and ensuring thermal comfort for employees, as well as improving the quality of microbiological purity.

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ZAGROŻENIA MIKROBIOLOGICZNE W MIEJSCACH ŻYWIENIA ZBIOROWEGO NA WYBRANYCH PRZYKŁADACH

Abstrakt

W zakładach żywienia zbiorowego występuje bardzo wiele zagrożeń związanych z bezpieczeństwem zdrowotnym produkowanej tam żywności. Do najistotniejszych zagrożeń mikrobiologicznych należy zaliczyć: wirusy, priony, bakterie, pleśnie i ich toksyny oraz pasożyty. Wymienione czynniki biologiczne są niebezpieczne dla osób uczestniczących w procesie produkcji żywności, jak i dla konsumentów. Wymagana jakość mikrobiologiczna posiłków podawanych w gastronomii jest bardzo istotna z uwagi na ryzyko występowania zbiorowych zatruć pokarmowych. Celem artykułu jest ocena czystości mikrobiologicznej powierzchni, rąk personelu i urządzeń technologicznych wykorzystywanych podczas produkcji żywności z uwzględnieniem wybranych parametrów mikroklimatu. Analizie poddano trzy zakłady żywienia zbiorowego, jeden typu otwartego oraz dwa typu zamkniętego. Badania czystości mikrobiologicznej powierzchni przeznaczonych do produkcji żywności wykonano przy użyciu luminometru 3M™ Clean Trace™ NGi oraz kompaktowego rejestratora mikroklimatu AXIOMET AX-DT100, wyposażonego w dokładny czujnik temperatury i wilgotności powietrza. Otrzymane rezultaty badań porównano z wartościami referencyjnymi następnie zaproponowano plan naprawy warunków higienicznych w rozpatrywanych zakładach gastronomicznych. Analiza wyników przeprowadzonych badań, dotyczących czystości mikrobiologicznej w wybranych zakładach żywienia zbiorowego, wykazała dopuszczalne przekroczenia referencyjnych limitów zanieczyszczeń.

Słowa kluczowe: zagrożenia mikrobiologiczne w żywności, zakłady żywienia zbiorowego ludzi, pomiary zanieczyszczeń mikrobiologicznych