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FACTORS DETERMINING MICROBIOLOGICAL QUALITY OF DISHES PRODUCED IN COOK-CHILL TECHNOLOGY

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Key words: cook-chill technology, microbiological state of dishes, hands cleanness, hygienic condition of equipment

Analysing the principles of producing dishes using the cook-chill technology it is possible to distinguish significant factors, potentially influencing microbiological quality of dishes prepared in this technology that is their durability and usefulness for consumption. The study was aimed at verifying factors that determine microbiological quality of meat dishes prepared in cook-chill technology, in the conditions of catering establishment serving meals to 3,000 persons. The factor determining the quality of dishes prepared in the cook-chill technology is the time of chilling after heat treatment. As a result of the carried out optimization of the process of blast chilling it was found out that maintaining the assumed technological regimes during chilling the dishes in portions is possible only after storing them in one layer in GN container. In the case of semi-liquid dishes it is necessary to use containers GN 65 mm, as in the higher containers the time of chilling exceeded 240 min. Microbiological testing (determining Total Plate Count and Total Count of Psychrotropis) shows that microbiological state of the dishes is determined, in high degree, by the cleanness of appliances (for mechanical treatment of food) and hands of employees.

INTRODUCTION

In order to be in control of the health quality and safety of catering dishes the technological process should be carried out so that the possibility of multiplication of pathogenic microorganisms is limited. The newest technologies of food production create a possibility to extend the durability of dishes by chilling. To this end, in mass nutrition establishments cook-chill technology is used. This technology consists in carrying out complete heat treatment of semi-finished products, and then their very quick chilling and storage under controlled conditions at temperatures below +3°C. It gives a possibility to avoid multiplication of microorganisms by very quick transition through the dangerous temperature zone (5-60°C) which favors the growth of microorganisms [Light *et al.*, 1990; Zalewski, 1999, Creed, 2001; Rybka-Rogers, 2000]. Employing this technology requires strict abiding by certain regime and using proper catering equipment.

The research was aimed at evaluating factors that determine the microbiological condition of meat dishes, prepared in cook-chill technology, in the conditions of catering establishment serving dishes to 3,000 persons.

MATERIAL AND METHODS

The scope of work included: (1) selection of parameters of blast chilling meat dishes after heat treatment consisting in determining the shortest time of chilling to a temperature of 3°C, in GN1/1 containers of different height; (2) determining the total number of microorganisms and total number of psychrotrophs: in meat dishes after heat treatment and during 6 days of storage at +3°C and in raw meat minced in laboratory conditions and in the conditions of catering establishment (equipment for mechanical processing of food); and (3) evaluation of the effectiveness of washing hands by the staff.

The material for research was 3 types of meat dishes: hamburger, meat balls, goulash prepared in the working conditions of the catering establishment belonging to the type of institution catering. Selection of this type of establishment resulted from the fact that as much as 36% of registered incidences of food poisoning occur after eating dishes produced in such catering establishments [Yi-Mei Sun & Ockerman, 2005].

Heat treatment of dishes. Parameters of heat treatment of dishes were presented in Table 1. At the moment of completion of heat treatment all the dishes had a temperature of 75°C in their geometrical centers.

Selection of parameters of blast chilling. Selection of the most favorable parameters of the blast chilling process was performed using a blast chiller with the capacity of 20xGN1/1 adapted to house trolleys from a convection oven. The examinations were performed with full load of the blast chiller. Time of chilling the dishes from the temperature of 65°C to the temperature of +3°C was measured, depending on the capacity of GN containers used. Containers 20, 40, 65, 100 and 150 mm

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TABLE 1. Parameters of heat treatment of the tested dishes.

Dish	Parameters of heat treatment
Hamburger	Frying on a frying pan (fat temperature 180°C), then heating in a combi-steamer in covered containers GN 1/1 20 mm at the temperature of 95°C without evaporation for 15 min.
Meat balls	Heat treatment in a combi-steamer in container GN 1/1 20 mm at the temperature of 180°C without evaporation for 20 min and then with 50% evaporation for 20 min.
Goulash	Preliminary frying on a frying pan (fat temperature 180°C) for 20 min and then stewing in a stewing pot for 120 min.

deep were used for examinations. The temperature was measured in the geometrical center of the dish by means of a probe installed by the manufacturer of the equipment. Time of chilling was measured by means of a stopwatch. Optimization of the blast chilling process was done in 3 samples for each dish with the assumed depth of GN container.

Determining microbiological condition of semi-finished meat products and ready dishes. Evaluation of the microbiological condition of meat semi-finished products (minced meat) was carried out by determination of total plate number of aerobic microorganisms (Total Plate Count - TPC) and total number of psychrotrophs (Total Count of Psychrotropis - TCP). Determination was carried out using plate method on nutrient agar (Noack Polen) [Noack Polen Instruction, 2006], according to PN-A-82055-6:1994 PN-85/A-82051, ISO-17410:2003 and instruction of preparing agar of Noack Polen company. In the case of determining TPC the samples were incubated at the temperature of 37°C for 48 h, in the case of TCP determination the incubation temperature amounted to 7°C and the time of incubation was 10 days. The tests were repeated 8 times.

Evaluation of the effectiveness of washing hands. Cleanness of staff hands was evaluated by two methods: direct – by agar imprints and indirect – measurement of bioluminescence. In the direct method the employees left imprints of three fingers on Petri dishes with nutrient agar, covered with sterile nutrient agar poured in laboratory conditions. The plates were incubated at the temperature of 37°C for 48 h. Reading of the dishes was carried out by counting microorganism colonies.

In the indirect method a measurement of bioluminescence was carried out in Unilyte appliance (Noack Polen) using the tests supplied to the user by the distributor of the appliance. The sample was collected from the fingers of employees, by means of swab rod, being an integral part of the test. After swabbing, the swab rod was placed inside the test. Making a test (in accordance with the instruction of the appliance) consisted in releasing reagents enabling the reaction of releasing and decomposing ATP.

RESULTS AND DISCUSSION

Analysing the principles of producing dishes using cook-chill technology it is possible to distinguish significant factors, potentially influencing microbiological state of the dishes prepared in this technology, and also their durability and usefulness for consumption. Such factors include: quality of raw materials or semi-finished product designed for heat treatment (standardization of recipes), time of chilling after heat treatment and temperature in the geometric center of the dish, hygiene of the personnel, and also hygienic condition of the equipment [Blakeslee *et al.*, 1999].

Selection of parameters of the blast chilling process

Time of chilling and final temperature of dishes are significant parameters of the cook-chill technology which determine the period of storing the dishes. These parameters are legally defined in the standards of many countries, however they are not uniform. In the United Kingdom and Japan it is required that the temperature at the completion of chilling amounts to +3°C and is reached during the period not exceeding 90 min, in Sweden +3°C during 240 min, in Denmark +5°C during 180 min and in France and Germany +3°C during 120 min [Evans *et al.*, 1996].

The differences concern also the temperatures and time of storing the prepared dishes. The maximum time of storing the dishes prepared in the cook-chill technology at temperatures from 0 to +3°C in the United Kingdom amounts to 5 days, while in Sweden and Denmark the time is limited to 3 days, in Japan it amounts to 4 days. In France and USA the recommended temperature of storing dishes amounts to 5°C [Majewski, 1997] According to Light & Walker [1990], the best quality and microbiological safety is reached using the temperature of +3°C, where even anaerobic spores of Clostridium do not sprout.

Due to a lack of Polish standards concerning the parameters of preparing dishes in this technology: the time of chilling, final temperature of the product after chilling and the period of storage, it was necessary to establish marginal parameters of the process on the basis of literature [Light & Walker, 1990; Barrie, 1996]. In order to reach the longest possible storage time (4-5 days) the following assumptions were adopted: chilling to a temperature of +3°C in the geometric center of the dish in the period not exceeding 120 min. The results of the selection of parameters of chilling are presented in Table 2.

On the basis of the carried out tests (Table 2) it was affirmed that it is possible to chill quickly the smaller pieces of meals (hamburger, meat ball), which after the heat treatment must be stored in one layer in GN1/1 container 20 mm high. Determining the marginal parameters of chilling semi-liquid dishes (goulash) was a great problem. In order to accelerate the technological process, during the initial stage of optimization efforts were made to chill goulash in GN1/1 containers 150 mm and 100 mm high. Unfortunately in spite of diverse calibration of the equipment for blast chilling (lowering the temperature of blown air), reaching the assumed marginal parameters of the technology was not possible. The time of chilling goulash in GN1/1 containers, 150 mm and 100 mm deep, exceeded respectively 240 and 180 min, which disqualifies the possibility of using the cook-chill method. Satisfactory time of chilling to 120 min was obtained only in the case of GN1/1 65 and GN1/1 45 containers (omitted as impractical in use).

TABLE 2. Parameters of the chilling process of dishes adopted as a result of parameters selection.

Products	Repetition	GN 1/1 20*			GN 1/1 65*		
		Initial temperature	Final temperature	Time	Initial temperature	Final temperature	Time
Goulash	1				69.6	3	116
Goulash	2				65.4	3	121
Goulash	3				66.8	3.1	120
Average value					67.3	3	119
Meat balls	1	63.1	2.8	38			
Meat balls	2	65.8	3	54			
Meat balls	3	66.1	2.9	62			
Average value		65	2.9	51.3			
Hamburger	1	64.7	3	64			
Hamburger	2	65.9	2.9	70			
Hamburger	3	65.6	2.9	76			
Average value		65.4	2.9	70			

* after preliminary investigations considered as the most useful for the chilling process

TABLE 3. Results of microbiological determination of the dishes.

Dish	Bacterial count (log cfu/g)	Time of storage (days)													
		0		1		2		3		4		5		6	
		$\bar{x}$*	SD*	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	S
Goulash	TCP[1]	5.04	1.44	5.20	1.40	6.06	1.54	6.44	2.49	7.59	2.92	7.86	3.67	8.09	3.59
	TPC[2]	3.19	1.18	4.11	1.31	4.65	2.48	6.29	2.93	5.65	0.33	6.45	3.52	5.36	1.46
Meat balls	TCP	3.27	0.62	4.16	0.56	4.93	0.60	4.68	0.87	5.31	0.85	5.64	0.98	6.18	0.39
	TPC	2.51	0.92	2.97	1.24	4.34	1.07	4.45	0.40	5.22	0.57	5.18	1.16	5.63	0.94
Hamburger	TCP	4.65	0.68	5.04	1.47	5.66	2.00	6.27	2.33	7.58	2.74	8.09	2.35	8.21	3.26
	TPC	3.94	1.00	3.75	0.87	4.10	1.08	4.99	1.43	6.05	2.14	6.92	2.26	7.65	2.69

*$\bar{x}$ – mean value; SD – standard deviation; [1]TCP – Total Plate Count; [2]TPC – Total Count of Psychrotropis

Determination of the microbiological quality of dishes

TPC and TCP were determined in chilled dishes. Determination was performed on the day of production (zero sample) and on each day of storage (samples 1-6). Chilled dishes were stored for 6 days. The results of microbiological determination of the dishes are presented in Table 3.

In spite of the short time of chilling the dishes to the temperature of +3°C the results of microbiological testing of the dishes were not satisfactory. As a result attempts were made to determine the influence of the selected factors on the microbiological state of the dishes, in order to enable full introduction of the cook-chill technology in the establishment. Taking into account the literature data [Yi–Mei Sun & Ockerman, 2005; Blakeslee *et al.*, 1999; Coleman *et al.*, 1998] it was stated that it is necessary to analyse the hygienic condition of the equipment and cleanness of the hands of the employees, being one of the main factors determining the microbiological state of prepared dishes.

Determination of the influence of the hygienic condition of the equipment for mechanical treatment of food on the microbiological quality of meat semi-products

The hygienic condition of the equipment was determined by the indirect method through the testing of meat semi-product. Due to the fact that hamburger and goulash showed the highest microbiological contamination (after 2-3 days TPC and TCP exceeded permissible values – Table 3), the hygienic condition of meat mincer was checked (meat for hamburgers and goulash was minced in the same appliance) by determining the total number of microorganisms and the total number of psychrotrophs in meat minced in the conditions of catering establishment and laboratory (meat grinder was washed before mincing using professional washing products of Ecolab company, used in catering establishments). Meat used for mincing was taken from the same supply and lot. The results obtained are shown in Table 4.

TABLE 4. Results of microbiological testing of minced meat.

	Meat minced in catering establishment	Meat minced in laboratory conditions
OLD (cfu/g)	High level of microbiological contamination above the standard	5.58 (S=1.21)
OLP (cfu/g)	High level of microbiological contamination above the standard	5.49 (S=0.98)

Similar tests were carried out by Legnani and partners [2004], who tested fresh meat subjected to mincing. In 37 samples of minced meat the average value of OLD amounted to 5.25 cfu/g. This is the level similar to the results of microbiological tests of meat grinder under laboratory conditions. The results of testing meat grinder under conditions of the catering establishment indicate that the hygienic condition of meat grinder used at the establishment is bad and can be one of the factors determining the microbiological quality of the dishes prepared in the cook-chill technology. It is confirmed by the results of testing swabs collected from the appliance, where TCP level (cfu/cm^2) exceeded permissible values. As it results from tests conducted by Yi-Mei Sun & Ockerman [2005], 15-20% of food contamination may result from cross contamination from dirty surfaces of used appliances.

Evaluation of the effectiveness of washing hands

Examination of the effectiveness of washing hands was carried out at the moment of full readiness of the employees to carry out technological processes, *i.e*. at the working station just before starting work. First sample was collected at that time (before washing hands), and then the employees washed their hands and the second sample was taken (after washing hands). Part of the employees were examined to determine microbiological cleanness of hands (imprinting method) and the second part of the employees were examined to determine general cleanness of hand (ATP method). The ATP method gives immediate answer as to the number of microorganisms and remains of organic contaminations. From the point of view of evaluation of the hygiene condition it gives sufficient information to undertake adequate actions. This method consists in decomposition of chemical bonds included in ATP and results in emitting the energy in the form of light. The intensity of illumination is proportional to ATP content in the sample, *i.e.* to the number of living microorganism cells and remains of organic material. The intensity of light is measured by means of a luminometer and the result of measurement is given in the relative light units (RLU). The results obtained are presented in Tables 5 and 6.

Tables 5 and 6 show that most of the employees were ready to start working in spite of substantial contamination of hands. Washing hands resulted in removing 80% of contamination of hands. Taking into consideration the character of technological processes carried out in catering establishments, based in substantial part on manual activities, it can be assumed that hands constitute a serious source of cross-contamination of semi-finished products and ready dishes. It may be one of the principal factors determining microbiological

TABLE 5. Average values of evaluation of hands pureness before and after washing (imprinting method).

Employee	Microorganisms forming colonies per 1 cm^2 MFC		Degree of removing contaminations (%)
	Before washing hands	After washing hands	
I	360	25	93.0
II	270	150	44.4
III	450	75	83.3
IV	200	230	-
V	uncountable (several thousand)	500	-
VI	190	3	98.4
VII	250	0	100.0
VIII	10	6	40.0
IX	400	7	98.3
X	33	4	87.9
XI	105	6	94.3
XII	170	0	100.0
XIII	220	120	45.5
XIV	150	2	98.7
XV	75	0	100.0

TABLE 6. Average values of evaluation of hands pureness before and after washing (bioluminescence method).

Employee	Relative light units (RLU)		Degree of removing contaminations (%)
	Before washing hands	After washing hands	
A	20.111×10^3	5.125×10^3	74.5
B	5.430×10^3	3.523×10^3	35.1
C	17.443×10^3	7.249×10^3	58.4
D	2.459×10^3	309	87.4
E	6.916×10^3	298	95.7
F	42.334×10^3	106	99.7
G	4.770×10^3	98	97.9
H	1.584×10^3	114	92.8

condition of the dishes that is the factor determining proper functioning of the cook-chill technology. This has been confirmed by researches by Yi-Mei Sun & Ockerman [2005], who analysed risk factors and stated that about 25% of the cases of food poisonings may be caused by food contamination deriving from dirty hands.

CONCLUSIONS

1. The time of chilling dishes produced in the cook–chill technology, to obtain the temperature of +3°C in the center of the dish is determined by the capacity of GN container used and the type of dish.

2. It is possible to maintain the assumed technological regimes (*i.e.* reaching the temperature of +3°C in time of up to

120 min) during chilling the dishes in portions placed in one layer in a GN container.

3. The factors determining microbiological quality of the dishes are not only the parameters of the process of blast chilling but also the hygienic condition of the appliances for treatment of food used in production and personal hygiene of the employees (especially cleanness of hands).

REFERENCES

1. Barrie D., Infection control in practice. The provision of food and catering services in hospital. J. Hospital Inf., 1996, 33, 13-33.
2. Blakeslee K.M., Penner K.P., A case study of a school food service cook – chill operation to develop a HACCP Program. Airy, Food and Environmental Sanitation, 1999, 4, 257-267.
3. Evans J., Russell S., James S., Chilling of recipe dish meals to meet cook – chill guidelines. Int. J Refrig., 1996, 2, 79-86.
4. Coleman Ph., Griffith Ch., Risk assessment, A diagnostic self-assessment tool for caterers. Hosp. Manag., 1998, 17, 289-301.
5. Creed P.G., The potential of food service systems for satisfying consumer needs. Inn. Food Sci Emer. Tech., 2001, 2, 219-227
6. Majewski J., Cook – Chill. Food Serv., 1997, 1, 26-28.
7. Noack Polen Instruction, Instruction of preparing media. 2006, Noack Polen Warszawa (in Polish).
8. ISO-17410:2003, Microbiological testing. Determining total number of psychrotrophs (in Polish).
9. Legnani P, Leoni E., Berveglieri M., Mirelo G., Alvaro N., Hygienic control of mass catering establishment, microbiological monitoring of food and equipment. Food Control, 2004, 15, 205-211.
10. Light N., Walker A., Cook–Chill Catering, Technology and Management. 1990, Elsevier Applied Science, London and New York, pp. 43-67.
11. PN-A-82055-6:1994, Meat and meat products. Microbiological testing. Determination of total bacterial count (in Polish).
12. PN-85/A-82051, Delicatessen products. Semi-finished products and ready products. Microbiological testing (in Polish).
13. Rybka-Rogers S., Improvement of Food Safety, Designing of Cook–Chill Foods. 2000, Centre for Advanced Food Research, University of Western Sydney, pp. 6-9.
14. Yi–Mei Sun, Ockerman H.W., A review of the needs and current applications of Hazard Analysis and Critical Control System in foodservice areas. Food Control, 2005, 16, 325-332.
15. Zalewski S., Dish production systems in mass feeding establishments. 1999, *in*, Convenient Food and Functional Food (ed. F. Świderski). Wydawnictwo Naukowo–Techniczne, Warszawa, pp. 148-155 (in Polish).

CZYNNIKI WPŁYWAJĄCE NA JAKOŚĆ MIKROBIOLOGICZNĄ POTRAW PRZYGOTOWANYCH W TECHNOLOGII COOK-CHILL

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Analizując zasady produkcji potraw przy zastosowaniu technologii cook–chill możliwe jest wyróżnienie istotnych czynników, potencjalnie wpływających na jakość mikrobiologiczną potraw przygotowywanych w tej technologii, a co za tym idzie, na ich trwałość i przydatność do spożycia. Celem badań była weryfikacja czynników warunkujących jakość mikrobiologiczną potraw z mięsa, przygotowywanych w technologii cook–chill, w warunkach zakładu gastronomicznego serwującego posiłki z przeznaczeniem dla 3000 osób. Czynnikiem warunkującym jakość potraw przygotowanych w technologii cook-chill jest czas schładzania po obróbce cieplnej. W wyniku przeprowadzonej optymalizacji procesu szokowego schładzania stwierdzono, że utrzymanie założonych reżimów technologicznych przy schładzaniu potraw porcjowanych możliwe jest jedynie po umieszczeniu ich jednowarstwowo w pojemniku GN. W przypadku potraw półpłynnych konieczne jest zastosowanie pojemników GN 65 mm, gdyż w pojemnikach o większych wysokościach czas schładzania przekraczał 240 min. Badania mikrobiologiczne (oznaczenie OLD i OLP) wskazują, że czystość mikrobiologiczna potraw determinowana jest w dużym stopniu czystością urządzeń (do obróbki mechanicznej żywności) oraz rąk personelu.