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CONTROL OF HACCP SYSTEM EFFICIENCY IN CREAM CHEESE PRODUCTION

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Abstract

Milk and dairy products are easily perishable food due to their composition and properties. Therefore, good hygienic practices and cooling system during milk manipulation are among main postulates in safe dairy production. Food safety is further improved by HACCP system application.

The aim of this research was monitoring efficiency of HACCP system set up in cream cheese production in Croatian Dairy Factory. Within this system, two critical control points were established: cheese pasteurisation and pasteurisation of additives. Process equipment, air and final products were assessed by classic microbial analysis and ATP bioluminescence method (where applicable) at different occasions during three month period.

The results showed that HACCP system was successfully applied in cream cheese production.

Key words: *HACCP system, cream cheese, ATP bioluminescence.*

1. Introduction

Milk and dairy products are highly valuable foods consumed often by highly sensitive population – children, pregnant women, elderly. In addition, public awareness directed towards food safety is increasing which additionally puts weight on food producers [1]. Dairy manufacturers have to evaluate their entire processes at all operation stages to ensure that products are free of pathogens such as *Listeria monocyogenes, Escherichia coli, Salmonella enteritidis, Salmonella typhimurium, Staphylococcus aureus,* aphlatoxin producing moulds etc [2, 3]. These pathogens are temperature-sensitive and destroyed during sterilisation process. However, since pasteurisation implies application of milder conditions, some of the microorganisms could survive the process. Therefore, highly developed and sensitive control system has to be applied in dairy production.

HACCP system has proved to be very efficient in ensuring food safety. It has been increasingly adopted by all food manufacturers ever since it has been public ally presented in 1971 [4]. After Codex Alimentarius published "Guidelines for application of the Hazard Analysis Critical Control Point (HACCP) system", HACCP principles have started to become legal obligation in many countries [5, 6], including Croatia [7].

After HACCP principles have been established in food premises, they have to be validated. Validation implies collection and evaluation of scientific and technical information to determine whether HACCP plan will effectively control hazards. A common approach to validation is conduction of scientifically valid experimental trials [8]. Bastin (1996) evaluated HACCP through microbial evaluation of food prepared by vacuum cook-chill system [9] and Martins & Germano (2008) assessed performance of HACCP system in meat lasagne production by microbial evaluation of samples collected in different phases of production process [10].

The aim of this research was to apply microbial evaluation in efficiency assessment of HACCP system established in cream cheese production. Traditional microbial analysis and ATP bioluminescence method were applied.

ATP bioluminescence is rapid surface control method that provides real-time estimation of surface contamination [11]. The principle of this method is based on firefly bioluminescence reaction. Namely, luciferase catalyses oxidative decarboxylation of luciferin in the presence of ATP and Mg^{2+}, resulting in light emission proportional to amount of ATP. Since ATP is ubiquitous in living cells, organic impurities (food residues) will impart reaction, and method does not distinguish

microbial contamination from organic residue [12]. Organic residues are indicator of insufficiently conducted sanitation processes and therefore this is not considered as disadvantage of the method in routine surface control. However, no information is provided on real count of microorganisms and the microbial species on the surfaces.

Nevertheless, ATP bioluminescence is recognised as valuable tool in microbial load control on hands, milking equipment cleanliness evaluation [13] and cleanliness and disinfection monitoring in dairies [11].

This research showed that HACCP system based on two critical control points (CCP): cheese pasteurisation and pasteurisation of additives was successfully established in cream cheese production.

2. Materials and Methods

2.1 Materials

Microbiological agars and broths were supplied by Biolife, and luciferin-luciferase complex ampoules Clean Surface ATP was supplied by 3M.

2.2 Methods

2.2.1. HACCP system implementation

HACCP system was set up according to Codex Alimentarius Guidelines.

2.2.2. Microbial cheese analysis [14]

Listeria monocytogenes was determined by enrichment method with Fraser broth and confirmation test on Aloe agar and Palcam agar.

Escherichia coli was determined by incubation of sample on brilliant green bile agar with Durham tubes with indole, methylene red, Voges-Proskauer and citrate confirmation tests.

Sulphite-reducing clostridia were detected by incubation in sulphite-agar and confirmation test on blood agar.

Salmonella was determined by enrichment method with selenite broth and incubation on SS agar and Wilson-Blaire bismuth sulphite agar. Confirmation was performed on Kligler double sugar agar, and then by urea, KCN and indole test.

Mould presence was detected by incubation on Sabourand maltose agar.

2.2.3. Microbial control of premises [14]

After sanitation, processing equipment was controlled to check efficacy of the process. Samples for microbial analyses were taken at different places at the production line shown in Table 3. Air quality was also tested at different locations at the production and packaging area, as shown in Table 4.

Swab test. Samples were collected by standard swab method at different places of processing equipment every 5 days, and incubated at 35 °C for 48 h in tryptic glucose yeast agar to determine total microbial count.

ATP bioluminescence. Special swab ampoules with luciferine-luciferase complex were used to examine 10×10 area at different places of processing equipment every 5 days. After 20 seconds reaction of sample with active complex ampoule was placed in luminometer Uni-Lite NG, Biotrace and values were recorded after additional 10 seconds.

Air quality. Air was analysed at nine different places in the factory. Open plate with Rose Bengal agar was left to stand for 15 minutes, incubated at 25 °C during five days and counted for moulds.

3. Results and Discussion

Production of cream cheese with determined critical control points is shown in flow chart (Fig. 1.). Hazard analysis showed that potential hazards are mainly controlled by application of Good Manufacturing and Good Hygienic Practices during production.

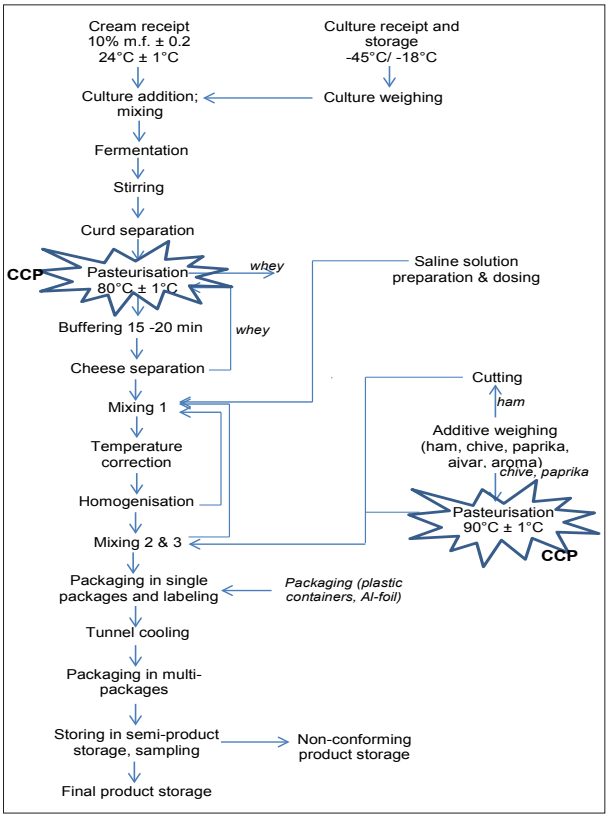

Figure 1. Cream cheese production flow-chart.

Two critical control points (CCP), however, have to be controlled within HACCP system, both pasteurisation processes (Table 1).

Table 1. Critical control points in HACCP system set up in cream cheese production

Critical control point – CCP1			
Phase		**Hazard**	**Critical limit**
8.0 Pasteurisation 80 °C ± 1 °C 8.1 Buffering 15 – 20 min		MB: survival of pathogenic microorganisms (aerobic mesophillic bacteria, *Salmonella*, *Escherichia coli*, sulphite-reducing clostridia, *Listeria monocytogenes*) due to improper pasteurisation temperature and/or time	Temperature: 79 °C Time: 15 min
Monitoring procedures			
What	**When**	**How**	**Who**
Pasteurisation temperature Pasteurisation time	Continuously during pasteurisation Before start-up of pasteurisation	• Control of starting and final temperature for every batch in buffer tank. • Control of thermograph records to assure that thermograph and probe detect same temperature. • Control of vital equipment for temperature regulation (probes, valves, thermograph, …)	Employee at preparation and production of fresh cream cheeses
Corrective measures Who, how		**Verification What, who, when**	**records**
If temperature is not correct for any reason (equipment or power failure etc.), employee at preparation and production of fresh cream cheeses discharges curd to balance tank and circulate it to pasteurizer. At same time, manager of line is informed and he decides on further actions and informs manager of maintenance if necessary. In case of prolonged hold up, curd is forced out from pasteurizer with water and pasteurisation process is stopped until cause is eliminated.		Thermograph record control. Line manager, daily. Lab control, microbiologist, every production date. CCP record control, line manager, daily. Internal audit, auditors, according to audit plan. Maintenance plan – maintenance division, according to plan. Measuring equipment calibration, externally, by legal requirements. PC manager verifies corrective measures after deadline for conduction.	Pasteurizer thermograph record. Microbial analysis. CCP 1 control record. Internal audit plan. Maintenance plan. Records of authorised institution about calibration or internal calibration record. Corrective/preventive measure claim.

Critical control point – CCP 2			
Phase		**Hazard**	**Critical limit**
19. Pasteurisation 90 °C ± 1°C /5 min chive; 3 min paprika		MB: survival of pathogenic microorganisms (aerobic mesophylic bacteria, *Salmonella*, *Escherichia coli*, sulphite-reducing clostridia, *Listeria monocytogenes*) due to improper pasteurisation temperature and/or time	Temperature: 89 °C Time: 5 min chive; 3 min paprika
Monitoring procedures			
What	**What**	**What**	**What**
Pasteurisation temperature Pasteurisation time	Continuously during pasteurisation Before start-up of pasteurisation	• Visual reading at command board screen of Stephan cuttera • Control of vital equipment for temperature regulation (probes, valves, thermograph, …)	Employee at preparation and production of fresh cream cheeses
Corrective measures Who, how		**Verification What, who, when**	**Records**
If temperature is not correct for any reason (equipment or power failure etc.), employee at preparation and production of fresh cream cheeses discharges curd to balance tank and circulate it to pasteurizer. At same time, manager of line is informed and he decides on further actions and informs manager of maintenance if necessary. After removing cause, process is repeated or batch is removed from production.		Lab control, microbiologist, every batch. CCP record control, line manager, daily. Internal audit, auditors, according to audit plan. Maintenance plan – maintenance division, according to plan. Measuring equipment calibration, externally, by legal requirements. PC manager verifies corrective measures after deadline for conduction.	Microbial analysis. CCP 2 control record. Internal audit plan. Maintenance plan. Records of authorised institution about calibration or internal calibration record. Corrective/preventive measure claim.

At critical control point 1 (CCP1) – cheese pasteurisation two types of hazards were identified:

1) microbiological – introduction of pathogenic microorganisms due to improper handling and survival of microorganisms due to insufficient pasteurisation time and/or temperature, and
2) chemical – contamination with sanitation chemical compounds due to insufficient washing.

Critical limits for CCP1 are: minimal temperature 79°C (maximum 81°C) and minimal time 15 minutes. During pasteurisation process, initial and final pasteurization temperatures are recorded and thermograph records are controlled to ensure that they are consistent with values at probe screen.

At critical control point 2 (CCP2) – pasteurisation of chive and paprika same hazards were identified as for CCP1. However, critical limits are different: minimal temperature is 89°C (maximum 91°C) and minimal time is 5 minutes for chive and 3 minutes for paprika. Here also, initial and final pasteurization temperatures are recorded and thermograph records are controlled continuously during process to ensure that they are consistent with values at probe screen.

HACCP system efficiency was verified by microbial control of final products and sanitation efficiency. Microbial analysis of final products (Table 2) showed that all samples had satisfying microbial quality – aerobic mesophillic bacteria count was below maximum limits defined by Croatia legislation [15] and pathogenic bacteria and moulds weren't detected in any of the samples.

Table 2. Microbial quality of cream cheese at the end of production process (analyses were conducted daily during 67 day period)

Product	SRK*	*Salmonella*	*Escherichia coli*	*Listeria m.*	AMB*	Moulds
Cream cheese 20 g	-	-	-	-	17 ± 13	-
Cream cheese 50 g	-	-	-	-	25 ± 15	-
Cream cheese 100 g	-	-	-	-	30 ± 30	-
Cream cheese 200 g	-	-	-	-	33 ± 20	-
Cream cheese with ham 100 g	-	-	-	-	29 ± 11	-
Cream cheese with ham 200 g	-	-	-	-	40 ± 20	-
Cream cheese with chive 100 g	-	-	-	-	25 ± 7	-
Cream cheese piquant 100 g	-	-	-	-	50 ± 10	-
Cream cheese with vegetables 100 g	-	-	-	-	15 ± 5	-

*SRK - Sulphite reducing clostridia; AMB - Aerobic mesophilic bacteria

Sanitation efficiency was assessed at different places at the production line (Table 3).

Table 3. Microbial control of cream cheese process equipment conducted by standard analysis (CFU*/mL) and by ATP bioluminescence (RLU*) method. Control was conducted every 5 days

SAMPLING PLACE	1. measurement		2. measurement		3. measurement		4. measurement	
	RLU	CFU/mL	RLU	CFU/mL	RLU	CFU/mL	RLU	CFU/mL
Milk tank wall	35	0	13	1	17	7	6	0
Milk tank cover	36	0	12	0	9	0	N*	N
Tank inlet	26	0	322	5	114	0	N	N
Cream ripening wall	N	N	20	4	11	0	N	N
Cream ripening cover	N	N	55	0	6	0	N	N
Pipeline – ripening inlet	53	43	N	N	N	N	209	80
Reception tube	16	6	13	4	16	0	23	0
Balance tube	4	0	8	0	10	0	17	0
Homogenizer - inlet	12	1	64	0	5	0	21	0
Reflux tube homogenizer	N	N	117	11	8	0	6	0
Homogenizer - outlet	N	N	5	0	8	0	29	0
Jet – after pasteurizer	N	N	10	0	11	0	6	0
Jet – temp. holder	N	N	35	0	55	4	N	N
Fermenter 1	12	0	12	0	N	N	8	0
Fermenter 2	10	0	8	0	8	0	N	N
Fermenter 3	20	0	17	0	10	0	9	0
Fermenter 4	12	0	8	0	75	0	11	0
Fermenter 5	9	0	21	0	13	0	14	0
Stephan cutter wall	12	0	N	N	N	N	11	0
Stephan cutter knife	17	0	N	N	N	N	10	0
Stephan cutter – vacuum tube	15	0	N	N	N	N	9	0
Pump for spreading	N	N	7	0	N	N	N	N
Mixer 1	10	0	12	0	6	0	10	0
Mixer 1 – homogeniser	94	4	10	0	13	0	8	0
Mixer 2	12	1	N	N	N	N	9	0
Mixer 2 – homogeniser	19	0	48	6	N	N	N	N
Dosing unit	13	0	16	0	N	N	18	0

*CFU - Colony-Forming Unit; RLU - Relative Light Units; N – not measured

Somewhat higher count of microorganisms after sanitation was detected by standard swab method at pipeline of ripening inlet (43 CFU/mL in 1st measurement and 80 CFU/mL in 4th measurement). However, cleaning efficiency was improving during the research - based on results of previous sampling, cleaning and disinfection procedures were improved in places at question.

ATP bioluminescence supported results obtained by standard method (Table 3). Baumgart reported that RLU value of 500 should be set as maximum corrective limit for assessing cleanliness by bioluminescence method [16]. However, Maletić, Bulajić & Kocić-Tanackov reported 200 RLU as maximum limit for mayo and ketchup [17] and Zagrajšek reported maximum of 300 RLU for dairy, with remark that if RLU ranges from 100 to 300 RLU, corrections in sanitation procedures should be made [18]. If Zagrajšek's limits are taken into account, ATP bioluminescence results showed that cleaning had to be corrected three times – two times in Tank inlet (after 2nd and 3rd analysis) and once in pipeline at ripening inlet. Sanitation procedures are efficient even if these results are taken into consideration. However, since standard method showed no microbial contamination, RLU values suggest that some organic residue is left after cleaning.

At the beginning of air quality monitoring, mould was present at all sampling locations, with highest incidence under ventilation (Table 4).

Table 4. Air mould presence in production and packaging area during three month period

Production	Total number of samples	Number of positive samples		
		1. month	2. month	3. month
Above weighing table	13	2	2	0
Above mixer 1 opening	13	1	2	0
Under Stephan cutter	12	3	3	2
Above Stephan cutter	12	4	2	0
Packaging				
Under packaging dosing unit	12	3	2	0
Above packaging dosing unit	13	3	1	0
Under UV lamp	11	2	3	0
By Al-foil charging	12	3	2	0
Under ventilation	13	7	2	1

As research progressed, the conditions improved significantly, and at the end moulds were detected on one occasion under Stephan cutter and under ventilation. HACCP system contributed significantly to air quality improvement in the dairy facility.

4. Conclusions

- HACCP system was successfully established in cream cheese production. Majority of hazards during the process was controlled by GMP and GHP and only two critical control points were determined - pasteurisation of cheese and pasteurisation of chive and paprika.
- ATP bioluminescence has proved to be convenient method for rapid, on-line assessment of sanitation efficiency. Major advantage of this method is short period of time in which results are gained, as opposed to standard swab method. In addition to microbial load, organic impurities are also detected, which is another indicator of cleaning efficiency.
- HACCP system significantly improved air hygiene in the facility.

5. References

[1] Jeličić I., Božanić R. and Krčmar N. (2009). *Implementation of HACCP system in production of UHT milk*. Mljekarstvo 59 (2), pp. 155-175.

[2] Valeeva N. I., Huirne R. B. M., Meuwissen M. P. M. and Lansink A. G. J. M. O. (2007). *Modeling farm level strategies for improving food safety in the dairy chain*. Agricultural systems 94, pp. 528-540.

[3] Chen H. (2007). *Use of linear, Weibull, log-logistic functions to model pressure inactivation of seven foodborne pathogens in milk*. Food Microbiology 24, pp. 197-204.

[4] Pierson M. D. and Corlett D. A. Jr. (Eds.). (1992). *HACCP principles and applications*. Van Nostrand Reinhold, New York, pp. 1-7.

[5] Al-Kandari D. and Jukes D. J. (2011). *Incorporating HACCP into national food control systems – analysing progress in the United Arab Emirates*. Food Control 22, pp. 851-861.

[6] Karaman A. D. (2012). *Food safety practices and knowledge among Turkish dairy business in different capacities*. Food Control 26, pp. 125-132.

[7] Croatian food law (Zakon o hrani). (2007). Narodne novine 46.

[8] Scott V. N. (2005). *How does industry validate elements of HACCP plan?* Food Control 16, pp. 497-503.

[9] Bastin S. (1996). *Validating HACCP through the microbial evaluation of food prepared by the vacuumized cook-chill system*. Journal of the American Dietetic Association 96 (9) Supplement, pp. A-41.

[10] Martins E. A. and Germano P. M. L. (2008). *Microbiologi-*

cal indicators for the assessment of performance in the hazard analysis and critical control points (HACCP) system in meat lasagne production. Food Control 19, pp. 764-771.

[11] Carracosa C., Saavedra P., Jaber J. R., Perez E., Grau R., Raposo A., Mauricio C. and Sanjuan E. (2012). *Monitoring of cleanliness and disinfection in dairies: comparison of traditional microbiological and ATP bioluminescence method*. Food Control 28, pp. 368-373.

[12] Ishida A., Yoshikawa T., Nakazawa T., Kamidate T. (2002). *Enhanced firefly bioluminescence assay of ATP in the presence of ATP extractants by using diethylaminoethyl dextran*. Analytical Biochemistry 305, pp. 236-241.

[13] Vilar M. J., Rodriguez-Otero J. L., Dieguez F. J., Sanjuan M. L. and Yus E. (2008). *Application of ATP bioluminescence for evaluation of surface cleanliness of milking equipment*. International Journal of Food Microbiology 125, pp. 357-361.

[14] Kiiyukia C. (2003). *Laboratory manual of food microbiology for Ethiopian health and nutrition research institute (food microbiology laboratory)*. www.unido.org/fileadmin/media/documents/pdf/.../MacroLab.pdf. Accessed 21 February 2013.

[15] Croatian legal requirements for animal origin food. Pravilnik higijeni hrane životinjskog porijekla (2007) Narodne novine.

[16] Baumgart J. (1996). *Hygiene monitoring by ATP determination HY-LITE(TM) system*. Fleischwirtsschaf 76: 272-273.

[17] Maletić Ž., Bulajić Ž. and Kocić-Tanackov S. *Primena HY-LITE detektora za ispitivanje higijene proizvodnih linija u prehrambenoj industriji*. <URL: http://www.novos.co.rs/documents/primena_hy-lite_detektora_za_ispitivanje_higijene_proizvodnih_linija_u_ prehrambenoj_industriji.pdf. Accessed: 21 February 2013.

[18] Zagrajšek G. (2008). *HACCP system in dairy plant*. Osijek, pp. 1-79.