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HACCP implementation in local food industry: a survey in Crete, Greece

Emmanouil Kokkinakis[a,b], Aikaterini Kokkinaki[a], Grigorios Kyriakidis[b], Anastasia Markaki[b], Georgios A. Fragkiadakis[b] *

[a] *Technological Education Institute (TEI) of Crete, Department of Commerce and Advertising, Ierapetra, Crete, Greece (manoskokkinakis@yahoo.gr; katrinakok@yahoo.gr)*

[b] *Technological Education Institute (TEI) of Crete, Department of Nutrition and Dietetics, Siteia, Crete, Greece (gregkyriakidis@staff.teicrete.gr ; markaki@staff.teicrete.gr; fragkiadakis@staff.teicrete.gr)*

Abstract

The aim of our survey was to evaluate the changes in the microbiological quality of locally produced/packed food following implementation of HACCP systems in: A. an ice-cream producing factory, B. a company preparing pre-packed sandwiches, C. a water-bottling company. Emphasis was given to the processing steps, transportation, storage and retailing. The results show the positive effects that a HACCP system, introduced in an ice cream factory, had on the microbiological quality of the final product and the total quality/hygiene management. Among others, two main hygiene problems were detected and corrected (E.N. Kokkinakis, G.A. Fragkiadakis, S.H. Ioakeimidi, I.B. Giankoulof, A.N. Kokkinaki, 2008, Microbiological quality of ice-cream before and after HACCP implementation: A factory case study. Czech Journal of Food Science, 26, 383-391). Concerning the sandwiches producing plant, no special food-safety problem was detected. The majority of the sandwiches were usually consumed within 1-3 days, however, indicator bacteria values cause concerns on possible dangers to human health and prove the necessity of monitoring the food-storage conditions at the retailer's level (E.N. Kokkinakis, G.A. Fragkiadakis, A.N. Kokkinaki, N.E. Lapidakis, 2011, Microbiological quality of pre-packed sandwiches at the retailing level, Acta Alimentaria, under revision). Finally, concerning the water-bottling company, the results indicated the need to improve the HACCP system, in order to continuously monitor the water-supply source, and to fully implement the correct storage conditions, hygiene procedures, and customer training at supermarkets (E.N. Kokkinakis, G.A. Fragkiadakis, A.N. Kokkinaki, 2008, Monitoring microbiological quality of bottled water as suggested by HACCP methodology, Food Control, 19, 975-961).

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Keywords: HACCP implementation; food industry; Crete; Greece

* Corresponding author. Tel.: +30-28430-29496; fax: +30-28430-26683.
E-mail address: fragkiadakis@staff.teicrete.gr

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1. Introduction

Small food-processing companies contribute substantially to the production, manufacture and retail of food in the periphery of most countries. For Crete, a leading destination depending on tourism and on the agro-food sector, the high quality/safety and prestige of the food offered in the island is crucial, in order to preserve the international recognition on the brand name "Crete" and on the "Cretan diet" healthy lifestyle.

The aim of our survey/study was to evaluate the actual changes to the microbiological quality of locally produced/packed food following the implementation of Hazard Analysis Critical Control Points (HACCP) systems in three different local enterprises: a. an ice cream producing factory, b. a company preparing pre-packed sandwiches, c. a water bottling company. Emphasis was given to the food processing steps, end-product transportation, storage and retailing.

2. Materials & Methods

We applied mainly Association of the Official Analytical Chemists (AOAC), and International Organization for Standardization (ISO) reference-methods, using the recommended pre-enrichments and selective enrichments; in addition, other methods as i.e. Petrifilm [1-4]. These methods were repeatedly utilized in our labs as routine procedures and were retained generally the same among several presented studies [1-4], to provide more comparable results.

3. Results & Discussion

The results of our survey show the extent of the positive effects that a Hazard Analysis Critical Control Points (HACCP) system, introduced in **an ice-cream factory**, had on both the microbiological quality of the final product as well as on the total quality/hygiene management. Among others, two main hygiene problems concerning the presence of the pathogen *Staphylococcus aureus* in the final product and the contamination of the mains-supply water with *Enterococcus faecalis* were detected and corrected [1].

The **bacterium *S. aureus*** is a most important agent of dairy products quality-deterioration worldwide. According to directive 92/46/EEC, for 5 ice cream samples representing 1 lot, all should contain *S. aureus* less than 100 CFU/g (Colony Forming Units per gram); however 3 should be at the satisfactory level of < 10 CFU/g, only 2 at the acceptable 10–102 CFU/g, and none > 102 CFU/g. Within the 3 ice cream lots we tested (3 lots vs. 5 samples each) before HACCP: one lot had 5 samples containing *S. aureus* (2 < 102 CFU/g, 3 > 102 CFU/g); one lot had 7 positive samples (3 < 102 CFU/g, 4 > 102 CFU/g); and one lot had 9 positive samples (6 < 102 CFU/g, 3 > 102 CFU/g). Overall, none of the three lots tested before HACCP was within 92/46/EEC requirements. However, after HACCP introduction, all samples, from 3 more lots tested, were found negative for *S. aureus* [1].

In this case study, **mains-supply water** was found contaminated with *E. faecalis*, possibly due to problems in the local water-supply pipelines system. Following HACCP implementation that introduced water-sanitation techniques (water chlorination, with free residual chlorine 0.2–0.4 ppm), the water used for the ice cream production and for personnel's washing were found microbiologically safe, and of potable quality. Active carbon filters were fitted into the water lines supplying ice cream ingredient tanks, to hold any residual chlorine from affecting the ice-cream sensory characteristics.

Microbial contamination of personnel's hands and surface samples (*Escherichia coli*, Total coliforms, and Aerobic Plate Counts) decreased after HACCP implementation (Figure 1), indicating that the introduction of personnel's training programs and Good Hygiene Practices (GHP) along with on the job training had a beneficial effect on the personnel's general hygiene. Plastic ice cream containers were found lowly contaminated, both before and after HACCP implementation (Figure 1). Further linkage of the HACCP system introduced in the factory to quality management systems, such as ISO 9001:2000, can

be possibly proved to provide higher quality/hygiene standards, along with higher awareness of the factories customers (i.e. ice cream retailers) [1].

Microbe	Personnel's hands		Containers		Surface after CIP	
	before HACCP	after HACCP	before HACCP	after HACCP	before HACCP	after HACCP
E. coli	–	–	75 (75 LC)	75 (75 LC)	25 (20 LC, 5 MC)	25 (25 LC)
Total coliforms	45 (15 LC, 30 HC)	45 (40 LC, 5 MC)	75 (75 LC)	75 (75 LC)	25 (10 LC, 15 HC)	25 (25 LC)
APC	45 (5 LC, 40 HC)	45 (40 LC, 5 MC)	75 (50 LC, 25 MC)	75 (70 LC, 5 MC)	25 (5 LC, 20 HC)	25 (25 LC)

APC – Aerobic Plate Counts; LC – Low Contamination; MC – Moderate Contamination; HC – Heavy Contamination

Fig. 1. Microbial contamination of personnel's hands and surfaces in the ice-cream factory studied [1]

Concerning the **sandwiches producing plant**, no special food-safety problem was detected, possibly due to the establishment of a HACCP system in the plant. The majority of the sandwiches were usually consumed within 1-3 days, however, indicator bacteria values (*Escherichia coli*, Enterobacteriaceae, Aerobic Colony Count) cause some concerns on possible dangers to human health (data not shown) and prove the necessity of monitoring the food-storage conditions at the retailer's level [2].

Microbial characteristics of water samples during storage at supermarkets

Microbial parameters	Final product (bottled water) stored at supermarkets					
	1st month storage (80 samples)		2nd month storage (80 samples)		4th month storage (80 samples)	
	Mean (log_{10}CFU/250 ml)	Range (log_{10}CFU/250 ml)	Mean (log_{10}CFU/250 ml)	Range (log_{10}CFU/250 ml)	Mean (log_{10}CFU/250 ml)	Range (log_{10}CFU/250 ml)
HPC (22 °C)	0.99	0.95–1.04	1.18	1.15–1.20	1.23	1.18–1.28
HPC (37 °C)	1.13	1.08–1.18	1.23	1.20–1.25	1.26	1.23–1.28

HPC: Heterotrophic plate count.

Fig. 2. Changes in the Heterotrophic Plate Count (HPC) levels, during storage of the bottled water [3]

All composite foods, which before consumption do not require significant further processing other than re-heating or completion of cooking, are included in the "ready-to-eat" category. Since, due to the modern way of life, the consumption of "ready-to-eat" food as pre-packed sandwiches increases, further research is needed on the logistics and retailing chain of this food. Especially in the Cretan summer, where the temperatures are high, the retailing conditions at mini-markets and kiosks are critical for safety [2].

Finally, concerning the **water-bottling company**, the results indicated the need to improve the HACCP system, in order to continuously monitor the water quality of the supply source in the plant, and to fully implement the correct storage conditions, hygiene procedures, and customer training at supermarkets [3]. The Heterotrophic Plate Count (HPC) at the 22 ^{o}C and 37 ^{o}C levels were found to be high in the drill water (all mean logCFU/250 ml 2.27, and 2.41, respectively), and decreased after filtration and bottling; (2.11, and 2.20, respectively, after 5 μm filtration); (1.79, and 2.00, respectively,

after 1 μm filtration); (0.86, and 1.04, respectively, after 0.2 μm filtration), and (0.96, and 1.11, respectively, for the final product) [3].

The **monthly storage in the supermarkets** did not seem to affect the microbial safety of the bottled water, since all the samples tested were within safety specifications. The contribution of plant's HACCP system was valuable in terms of transportation conditions of the bottled water, since the microbial quality of the final products did not change during the 1st month of storage in supermarkets. A small increase in Heterotrophic Plate Count (HPC) levels, during the 2nd and 4th month of storage (Figure 2), was within the safety limits with all the tested samples safe for human consumption [3].

Studies have shown that **bottling water with low HPC** initial levels changed very little after several months of storage. The results of our research are in agreement with these latter studies since very low HPC levels were recorded, both in the processed and bottled water and in the same bottled water batches at the supermarkets after 1–4 months of storage. Additional reasons that maintained the bottled water quality could be the training sessions that were provided to each supermarket in terms of water safety/hygiene and product storage in a controlled environment (i.e. air-conditioned storage at 20–22 ^{o}C) [3].

Both in the case of the **ice-cream factory** [1], as of course and in the **water-bottling plant** [3], the quality of the water source were proved crucial. The responsibility on this water quality concerns the local self-administration, since it is influenced by the potable water offered by self-administration companies [1], as well as by environmental parameters that influence spring-water quality [3]. Since, after the changes in the local-self administration in Greece (Kallikratis project), many self-administration companies that currently manage water supply and distribution will be closing, special attention must be given at the local level, so that the water quality to be sustained or improved if possible.

In the case of the ice-cream factory [1] **specific technical problems** arise, as i.e. whether the water must be chlorinated and what may be the effect of chloride in the final product. A question is whether such water, disinfected with chlorine, should be used at all in food industry; however in many rural areas there may be no other source of water for local industries. In the case of the water-bottling company [3], monitoring of the animal husbandry activities and the use of agricultural pesticides in the area is crucial in preserving the environment and the water sources.

Especially for the **agriculture-environment axis** and since the majority of the Greek farms are small-sized, the Agricultural Cooperation Associations should be encouraged to manage the application of Good Agricultural Practise (GAP) protocols [5]. The application of GAP protocols, as the AGRO 2-1 & 2-2, can reduce microbial hazards for food consumers and furthermore can establish agro-food practices in compliance to modern hygiene requirements [5].

4. Conclusion

In all the cases studied [1-3], HACCP implementation had a positive impact on company functioning, personnel professionalism, and raw-materials quality-standards, while it was effective in reducing average microbiological counts during food preparation. However, further attention is required, in order to sustain and improve the quality perception and the relevant practises of the local food-processing industry.

During the implementation of HACCP, this industry faces specific technical problems and challenges that require technical expertise, innovation and close cooperation with the local tertiary-education and research infrastructure that were established in Crete the last 25 years. This cooperation, in these years of economic crisis, is a prerequisite not only for preserving local-food safety but also for developing future innovation applications.

The food and drink industry, combined with tourism are of the most important income sectors in Crete and Greece in general. Beyond the teaching duties, that the members of this scientific group have, we feel obliged to stimulate the awareness of local food enterprises on the necessity of cooperation and of promoting innovation, in order to keep this sector competitive.

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