Implementation of Food Safety Management Systems in Small Enterprises in Cyprus

by

Marianna Charalambous

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Abstract

Implementation of food safety programmes has been difficult for small and medium sized companies (SMEs) in Cyprus, taking into consideration specific practises witnessed as common place amongst Cypriot food producers. SMEs tend to have a poor understanding of food management systems and limited adoption and implementation. The requirement for full food management implementation and the replacement of the national standards by the new ISO22000 in 2006 placed an even greater burden on these businesses.

The aim of this project is to compare food safety and hygiene before, during, and after implementation of food management systems assessing whether the implementation of food management systems in SMEs in Cyprus improves the hygiene and compliance with food safety requirements. A questionnaire survey was made of 50 SMEs (food industry sector) and an audit process was carried out, in companies that had not started the implementation of food management systems but intended to do so. Follow-up audits to the premises observed the process and the operatives to determine any changes to the level of food safety and hygiene. A benchmarking audit was carried out before, during, and after implementation of the system, and each company was rated. Results show that most respondents encountered many problems in applying and maintaining food management systems. Even if food management systems were applied, businesses did not alter their daily practices in a significant way.

To conclude, in order for small food enterprises to have in place workable food management systems, a generic, simple, and flexible food management system must exist. In addition, each enterprise has its own application limit regarding the complexity of the system. When this limit is exceeded negative results appear for the enterprise.

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List of Abbreviations

CCP	CRITICAL CONTROL POINT
CYS	CYPRUS ORGANIZATION FOR STANDARDIZATION
EU	EUROPEAN COMMUNITY
ΕΛΟΤ	GREEK STANDARDIZATION ORGANIZATION
FAO	FOOD AND AGRICULTURE ORGANIZATION
FDA	FOOD AND DRUG ADMINISTRATION
FSA	FOOD STANDARDS AGENCY
GHP	GOOD HYGIENE PRACTISES
GMP	GOOD MANUFACTURING PRACTISES
HACCP	HAZARD ANALYSIS CRITICAL CONTROL POINT
ICMSF	INTERNATIONAL COMMISSION ON MICROBIOLOGICAL SPECIFICATIONS FOR FOODS
ISO	INTERNATIONAL ORGANIZATION FOR STANDARDISATION
NACMCF	NATIONAL ADVISORY COMMITTEE FOR MICROBIOLOGICAL CRITERIA FOR FOODS
NASA	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NAS	NATIONAL ACADEMY OF SCIENCE
NMFS	NATIONAL MARINE FISHERIES SERVICE
NOAA	NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
PRP	PREREQUISITE PROGRAMS
USDA	UNITED STATES DEPARTMENT OF AGRICULTURE
WHO	WORLD HEALTH ORGANIZATION

1 INTRODUCTION

Safety and quality are important for the food industry. The Hazard Analysis Critical Control Point (HACCP) is a proven mechanism for controlling food safety. The HACCP approach is internationally recognized as essential for ensuring the safety and suitability of food for human consumption (Bas *et al.*, 2006; Pierson and Corlett, 1992; Ramirez and Fernandez, 2003; (EC) 852/04, 2004). Due to the main concern of consumers on the safety of food (Kidd, 2000) more and more countries require satisfactory food control programmes to ensure the safety, quality and availability of food supplies.

After Cyprus successfully joined the European Union in 2004, certain changes in Cyprus food safety legislation had to take place to comply with the relevant European Directives and Regulations. The need for a change and a more rigorous review of the safety procedures was consolidated by the growing public concern in Cyprus regarding the safety and the quality of the food.

1.1 Research Background

As presented by the Codex Committee on Food Hygiene in a meeting held in The Hague in April 1998 (WHO, 1999), it was recognized that small businesses have great difficulties in implementing the HACCP system and that the system was developed from the perspective of large food enterprises. It is possible to identify the main internal and external factors which may affect the decision of small and medium enterprise (SMEs) to adopt a quality assurance system.

Studies in HACCP implementation and operation in Cyprus have mainly focused on discussing the function of the HACCP system and on how to operate it in certain industry services such as the olive oil industry (Zorpas and Tzia, 2008). To date, there has been little investigation of Cyprus industry into the problems associated with the implementation of HACCP in SMEs. A recent study in Cyprus by Violaris *et al.* (2008) shows that the size of business is the best indicator of application of HACCP and that small business are lagging behind in ensuring safety of their products due to financial constraints. Angeli *et al.,* (2009) found that SMEs are facing problems in implementing environmental and food safety laws and regulations, especially when investments, infrastructure and employment are involved. This study investigates whether SMEs in Cyprus can apply the HACCP system, due to its complexity and the bureaucracy that presupposes, and have the required results concerning the safety of their products.

From 2004 to 2008, the researcher was employed in TUV Hellas certification body as an auditor, in the consultancy department of PricewaterhouseCoopers (PWC) as a consultant in implementing HACCP system and in the Cyprus Organization for Standardization (CYS), as a standardization officer. The CYS is responsible for adopting the European and international standards and for the development of national standards. The researcher’s employment background made possible an accurate collection and analysis of the data presented.

1.2 Motivation

Most of the food enterprises in Cyprus are family businesses and small enterprises. With the integration of Cyprus into the European Union in 2004, Cyprus legislation had to be harmonised with the European legislation, part of which were the food regulations (EC) 852/04 (2004) and (EC) 882/04 (2004) etc., which requires the application of the HACCP system. With this harmonization many difficulties have arisen in applying the mandatory HACCP system, in particular for SMEs. Government laws concerning food safety became strict. Non compliance to the regulations could result in a fine by the European Union. For this reason the Minister of Commerce, Industry and Tourism in Cyprus stated that any food enterprise that does not comply with the European Regulation will be closed down (Nicolaou, 2003). In order to fulfill the requirements of the European food regulation, food enterprises needed to implement a HACCP system. In order for a food enterprise to implement a HACCP system an external consultation was required. For a company that could apply both the regulation and the national standard CYS244 (CYS, 2001) a HACCP certificate was provided after a third party audit from a certification body. The national standard CYS244 was voluntary put in order to get a HACCP certificate enterprises needed to implement the standard. A HACCP certificate was an indicator that an enterprise follows the food hygiene regulations. Enterprises needed the HACCP certificate in order to get a government funding. In 2006, the national standard CYS244 was withdrawn and the new international standard ISO22000 (ISO, 2005a) was adopted by the CYS. With this change all food enterprises were expected to be harmonized with the new standard before their annual third party audit by the certification body. As a result, enterprises had to reshape their food handling resulting in new barriers. The consultants, the certification bodies, and also part of the government sector, began to earn money from SMEs by exploiting them, so that many enterprises had economic problems and some of them closed down (Vasiliou, 2003a). The cost for a consultation varied from €13700 to €26000 for a medium size enterprise (Vasiliou, 2003b).

Apart from economic problems, the application of the system generated problems on the observation of the documentation. For almost all SMEs application of HACCP was impossible even if the companies spent large amounts of money. This was due to the complexity of the system and the lack of appropriate infrastructure (Vasiliou 2003a). Many food business operators and employees did not have the required level of knowledge to cope with the extensive bureaucracy of the system. The above situation led the researcher to conduct an investigation on the implementation of the HACCP system by the SMEs in Cyprus.

1.3 Research Problem and Objectives

This research explores the required needs of SMEs in applying the food management systems, and the barriers that they face during implementation. It suggests a simplified implementation of systems requirements in particular for small food businesses. It investigates a simplified form of food management systems that small enterprises are able to apply and still maintain food safety. The European legislation (Article 5, EC852/2004) foresaw the need for flexibility when applied, in particular, to small businesses. This concept of flexibility allows food management systems' principles to be implemented in all cases, including SMEs. The flexibility and the kind of simplicity that can be used by SMEs are investigated in this research. In particular, the research tries to:

- Develop new strategies for implementing food management systems in SMEs.
- Assess whether there are benefits for SMEs in having food safety management systems in place and if so, whether the investments required for successful implementation justify the benefits
- Assess whether SMEs can apply food management systems due to their complexity
- Assess whether the implementation of food management systems in SMEs in Cyprus improves the hygiene and compliance with food safety requirements
- Review the difficulties experienced by small businesses in Cyprus when applying food management systems
- Investigate the food safety level of SMEs before, during and after the implementation of the system
- Investigate the extent to which the employees from the local enforcement authorities involved in the implementation of the system assisted the food businesses on implementing food management systems
- Investigate what kind of problems the managers and owners of SMEs encounter in applying and maintaining food management systems

1.4 Significance of the Study

Studies investigating problems associated with the implementation of HACCP in SMEs in Cyprus are still rare. This research investigates possible problems of the implementation of HACCP.

The first findings (after the implementation of the PRPs, level 2) of the research were presented in the seminar "In Food Hygiene / Legislation and Standards" held by CYS in Cyprus in March 2006[1] in the presence of the responsible government services from the Ministry of Health and the Ministry of Commerce, Industry and Tourism. The results from the research were taken into consideration by the government officials in order to be used in the promotion of a general drawing of a simplified HACCP guide, specifically for SMEs in Cyprus. As a result the generic HACCP plan "*Implementation of HACCP in SMEs: General HACCP Plan*"[2] has been produced by the Sanitary Services of the Ministry of Health in Cyprus. In the same seminar, results of the application of HACCP in small butcheries in the UK were also presented (Smith *et. al*, 2002). These results were used as an example for the creation of a similar generic HACCP plan for butcheries in Cyprus by the Cyprus Butcheries Association in 2006 entitled "*HACCP Handbook for Butcheries*"[3].

The results of the study have a wider global significance and are applicable to both EU countries and globally in general. SMEs constitute the majority of food enterprises

[1] Information of the seminar available from CYS
[2] Available on request from the Sanitary Services of the Ministry of Health, Cyprus.
[3] Available on request from the Cyprus Butcheries Association.

in many countries and are the enterprises facing most difficulties and barriers when implementing food management systems.

2 LITERATURE REVIEW

2.1 Introduction

Food hygiene and safety is a subject that concerns each one of us and is of primary importance. Many consumer organizations call for healthier food. The European Union is the responsible body for setting up the foundations for a wider application of the food safety principles through which the food industry should operate (production, manufacturing, packing, distribution, disposal, storage, and sale). For reducing the public health risk arising from food contamination both managers and legislators seek a risk-based food hygiene management system (Anon, 1998; Anon, 2004; WHO, 2004). The roots of the HACCP system go back to the end of the 1950's, in the laboratories of the National Aeronautics and Space Administration (NASA) (Bauman, 1995). HACCP system is recommended by *Codex Alimentarius Commission,* the Food and Agriculture Organization (FAO) and the World health Organization (WHO) for ensuring the safety of food products (Codex Alimentarius Commission, 1995).

A new regulation for the Hygiene of Foodstuffs (EC) No852/2004 introduced by the European parliament mandated all food operators from member states to comply with the HACCP based system. The HACCP system ensures the production of a safe product by controlling the food safety hazards (Mortimore & Wallace, 1998). This is achieved by tracking down those points where there is potentially a risk of food contamination. This risk can be due to

- Physical hazards. By physical hazard we mean the appearance in the food of a foreign object, emanating from the personnel, the plant and in general from the equipment. The consequences of such a risk could be injury or cause of illness for the consumer, though physical hazards do not occur frequently (Riswadkar, 2000)

- Chemical hazards. The chemical hazard is due to the existence of either additives, or natural and chemical substances in the product. These may include toxins, hormones antibiotics, pesticides, etc (Motarjemi and Mortimore, 2005)

- Biological hazards. The biological hazard is perhaps the one that requires the highest level of caution due to the existence of micro-organisms that can multiply very rapidly in the absence of the correct conditions of thermal treatment, storage etc. This hazard can easily be a part of a safety system (Motarjemi and Mortimore, 2005).

2.2 HACCP Overview

HACCP was initially developed as a food hygiene system against microbiological factors, and was used in the space program of the United States (FSRIO, 2005; Wallace and Williams, 2001). It became clear that safe products could only be produced if there was the possibility of controlling 100% of the production, something that is impossible. Thus, it was clear only a system such as HACCP could be useful and prevent problems (Ehiri *et al.*, 1995). The HACCP system comprises a sequence of simple steps that must be taken during the production of the food, including all handling that takes place from the production up to the consumption of the product, to ensure a sure and healthy final product and thus the health of the consumer.

2.2.1 History of HACCP

The main states of development of HACCP are briefly presented in chronological order.

In 1959 the American company Pillsbury Co, in collaboration with NASA and the US Army laboratories, undertook the production of safe food for consumption from crews of space expeditions, under conditions of no gravity (Bauman, 1995). This presupposed that the produced food would not be contaminated by micro-organisms that could cause illnesses and lead to premature termination of the mission. Existing techniques of Qualitative Control were considered insufficient for ensuring 100% safety of the products, so a preventive control system was developed that was based on the quick control of raw materials, the activities, production plants, personnel, storage and delivery, thus reducing dependence on finished product sampling and testing. The requirement for keeping files according to the regulations of NASA facilitated both the layout and the application of the HACCP system and constitutes a basic part of its current form.

In 1971, the HACCP concept was presented for the first time at the first National Conference on Food Protection (Pierson & Corlett, 1992). In this stage the system included only three basic principles: 1) Assessment of hazards / hazard analysis, 2) Determination of Critical Control Points (CCPs) required to control any identified hazard, and 3) establishment of procedures to monitor CCPs. In 1972 the Pillsbury Company signed a contract with the FDA, to conduct a training program for the Organization's personnel on the HACCP system, and WHO presented the application of HACCP for food safety in a conference held in Argentina. In 1973 Pillsbury Company published the first comprehensive treatise on HACCP (Pillsbury Company, 1973), which was used to train FDA inspectors in HACCP principles. During this year – based on the HACCP approach – the first audits from the FDA took place, in Low-Acid Canned Food (LACF) in the USA. The HACCP constituted the basis, on which the FDA promulgated the Regulations in 1974 for LACF (Cato, 1998; FDA, 1973; FSRIO, 2005).

During 1980 the WHO recognized that the HACCP system was unknown outside the US, and that it should be applied in other countries. In 1985 the USA National Academy of Sciences (NAS) with the publication of the famous "green book", *An Evaluation of the Role of Microbiological Criteria for Foods and Foods Ingredients* (NAS, 1985), recommended the HACCP system for preventing microbiological hazards in food. It stressed that analyses on the final product are not sufficient for the prevention of food poisoning and proposed the establishment of new modern principles for HACCP, training of the personnel in these principles, as well as the constitution of the National Advisory Committee on Microbiological Criteria of Foods (NACMCF). In 1987 the National Oceanic and Atmospheric Administration (NOAA) was assigned the planning of a program aiming on the improvement of the inspection of the fishery industry with the application of the HACCP system, the responsibility for which was held by the National Marine Fisheries Service (NMFS). Next year, in

1988, the International Commission on Microbiological Specifications for Foods (ICMSF) published the book *Microorganisms in foods 4: Application of the HACCP system to ensure microbiological safety and quality* (ICMSF, 1988). The WHO proposed the application of the HACCP system in the preparation of foods as well as the training of personnel that handles the foods. In 1989 NACMCF published a guide entitled “HACCP Principles for Food Production” (NACMCF, 1989). This guide was a generic manual for the application of HACCP, including uniform definitions, the seven HACCP principles as discussed in section 2.2.3, and a description of the application of each principal.

In 1991 the NMFS completed the research on the application of HACCP in the seafood industries. The research received the name MSSP (Model Seafood Surveillance Project) (Garrett and Hudak-Roos, 1991). In 1992 the European Union adopted a directive (Council Directive, 92/5/EEC), which focused on the meat products and in the correct application of the principles of HACCP. In the same year NACMCF updated the 1989 HACCP system document. Changes included a new risk assessment procedure and modifications for making the system easier to use (NACMCF, 1992). In 1993 the Joint FAO/WHO *Codex Alimentarius Commission* adopted guidelines on the application of the HACCP system. The former European Community also adopted the directive on hygiene and foodstuffs 93/43/EEC in which it stressed the importance of good hygiene and the use of HACCP in the food industry in all stages of production. With directive 93/43/EEC the application of HACCP became mandatory for the food industries of the European Union, aiming to an increase in their competitiveness (Ropkins and Beck, 2000). In 1994 the United States

Department of Agriculture (USDA) published generic HACCP models for refrigerated foods that constituted guides on the application of HACCP in the industries of meats and poultry. Moreover, the Joint FAO/WHO *Codex Alimentarius Commission* drew up a preliminary draft publication on the General Principles of Food Hygiene. This publication studied the food production from the growth of raw material up to the consumption of products, and detected in each stage the basic hygiene controls that had been internationally recognized as essential for the guarantee of safety for consumption of foods.

In 1995 WHO with the participation of FAO organized a consultation on the *Hazard Analysis Critical Control Point System: Concept and Application* (Geneva, June 1995) with the following objectives:

- examine the problems that arise with the application of guidelines of *Codex Alimentarius* and to submit proposals on the renewal of the Code, and
- to develop strategies for the implementation of the HACCP system at national level.

In 1997 the *Codex Alimentarius Commission* revised the 1993 HACCP guidelines (CAC, 1997). In 2004 the directive 93/43/EEC of the 14 June 1993 on the hygiene of foodstuffs was replaced by the European regulation (EC) No 852/2004.

2.2.2 Benefits and Barriers

The adoption of HACCP by food companies may have many clear benefits. An awareness of these benefits is important in order to implement the system effectively. In the literature there is a substantial number of studies that have publicised the benefits and drivers of the adoption of HACCP by the food industry.

In a survey of food companies' perception, in Greece, Semos and Kontogeorgos (2007) reported that the benefits derived from HACCP implementation are due to three factors: clientele benefits, product improvements, and improvements in production procedures. Studies revealed that implementation of HACCP can help trade between countries and increase export sales (Cato, 1998; Maldonado *et.al.*, 2005; Panisello and Quantick, 2001; Taylor, 2001). As stated by Jensen and Unnevehr (2000) the implementation of the system helped companies in the USA to access international markets.

Other benefits of HACCP as stated in the literature include; an improved relationship between food companies and regulatory authorities; better use of resources and continuous inspection; compatibility to other management systems; reduction of microbial counts in products; increase in food handlers' awareness of the HACCP and food safety; reduced waste and downtime (such as Gorman *et.al.* 2002; Griffith *et.al.*, 2003; Soriano *et.al.*, 2002; Tuominen *et.al.*, 2003; Van Schothorst, 2004).

Despite these proclaimed benefits there are many barriers to the application of a system like HACCP. Many authors including Panisello and Quantick (2001), Mortlock *et. al.* (1999), Panisello *et. al.* (1999) and Ward (2001) have suggested that the level of knowledge of employees, the time constraints, and the additional documentation required are the most important barriers. These barriers are not on the same magnitude to all enterprises but vary according to their size, knowledge and resources. Particularly small and family enterprises face many barriers in implementing the system. As HACCP is a demanding safety quality assurance concept it is not reasonable to expect SMEs to implement it right away. A number of barriers are impeding HACCP implementation to SMEs that can lead to waste of time and money due to financial constraints, lack of expertise and/or technical support, availability of government support etc. (see for example Azanza and Zamora-Luna, 2005; Taylor and Kane, 2004; Walker *et al.*, 2003; WHO, 1999). With the application of HACCP an enterprise could face financial barriers due to the need to engage specialized personnel or external consultants, buying the essential equipment or even the expenditure of large amounts of time on the training of the personnel involved in the HACCP team.

Mortimor (2003) states that due to the lack of knowledge of the people inside the company on microbiological and toxicological issues companies have to seek help from outside. As a result implementation of the system becomes very complicated. A study by Violaris *et. al.* (2008) in food businesses in Cyprus reveals that due to complexity only 17% of food companies implement the HACCP system. Another study by Panisello *et al.*, (1999) shows that as the number of employees decreased in companies with less than 50 employees, HACCP implementations decreased proportionally.

However, the use of a simplified form of the system can counterbalance all the negative facts given above by providing an improvement in the safety of the products. The time interval between the development of the HACCP program and the final implementation varies depending on the type of industry. The difficult part is the determination of hazards and of the CCPs, training of the employees, the acceptance by the employees of the changes that the system incurs in their every day work, as well as the change in attitude.

2.2.3 HACCP Principles

Effective HACCP implementation is important for avoiding an adverse human health and economic consequences of food born illnesses. There are seven principles necessary to establish, implement, and maintain a HACCP plan. These principles, as described by NACMCF (1992) and Codex (1997), are:

Principal 1: *Conduct a hazard analysis. Prepare a list of steps in the process where significant hazards occur and describe the preventative measures.*

The first principal describes the starting point for the HACCP team. This includes a flow diagram that has to be constructed outlining the various steps, from raw materials to the final product. In what follows, all hazards occurring at each step are identified and preventative measures are suggested. These hazards may include biological hazards, physical hazards and chemical hazards. Foodborne biological hazards consist of microbiological organisms like bacteria parasites and viruses. Most of these are killed during cooking or can be minimized by an adequate control. Physical hazards include injuries and illnesses due to foreign objects in food, like glass, plastic, pests etc. Chemical hazards include toxic metals, cleaning chemicals and others.

Principal 2: *Identify the critical control points (CCPs) in the process.*

For each enterprise a HACCP team was created consisting of 2-5 personnel. The next step that the HACCP team must make is to establish the CCPs, that is, points or procedures in food manufacturing at which control can be exercised to reduce the possibility of a food safety hazard**.** The importance of CCPs lies on the fact that any faulty operation at this stage gives a high probability of a health hazard occuring (Jouve, 2000). The identification of a CCP can be achieved by many methods, the most common being the use of a decision tree (Bryan, 1996).

Principal 3: Establish critical limits for preventative measures associated with each identified CCP.

Critical limits have to be established for each CCP. These limits represent boundaries used to judge whether or not an operation produces safe products and may be derived from a variety of sources. They are set for observable or measurable parameters which can demonstrate control of the critical points. Parameters may include temperature, pH, visual appearance, texture etc. (Pierson and Cortlett, 1992; Jouve, 2000).

Principal 4: Establish CCP monitoring requirements. Establish procedures from the results of monitoring to adjust the process and maintain control.

Monitoring requirements for managing each CCP within its critical limits have to be specified by the HACCP team. Monitoring enables the producer to show that the conditions of production comply with the HACCP plan. It includes performance measurement of the level of the system’s operation at a CCP, establishment of a record reflecting the performance level of the operation at a CCP and detection of loss of control at a CCP.

Principal 5: Establish corrective actions to be taken when monitoring indicates a deviation from an established critical limit.

The HACCP team has to plan in advance corrective actions for each CCP. Corrective actions may include identification of the individual responsible for implementing these actions, record of the measures taken with all relevant information, description of actions required to correct the observed deviation etc (Motimore and Wallace, 1994; Jouve, 2000).

Principal 6: Establish effective record keeping procedures that document the HACCP system.

For the application of a HACCP system efficient records must be kept and HACCP procedures should be well documented. These will result in safe product manufacture.

Documentation should be assembled into a user-friendly manual that is accessible for reference. It should include a record of the decision taken during the HACCP exercise (Mayes, 1999).

Principal 7: Establish procedures for verification that the HACCP system is working correctly.

The HACCP team should set-up a verification system to maintain the HACCP system and ensure the continuation of its effective work. The system may involve microbiological and other tests, internal audits etc. The aim is the verification of the appropriateness of the original HACCP procedure and the proper application of corrective actions and monitoring of procedures (Mortimore and Wallace, 1994; Khandke and Mayes, 1998).

2.3 Parameters for Applying the HACCP System

The application of the HACCP system is related to three important parameters:

- Legislation,
- Prerequisites Programs (PRPs) and
- National and International Standards.

The food legislation in Cyprus is the same as the European legislation. The PRPs for HACCP include Good Manufacturing Processes (GMP), Good Hygiene Practices

(GHP), Standard Operating Procedures (SOPs), Sanitation Standard Operating Procedures (SSOP), and Good Agricultural Practices (GAP) (FSRIO, 2005; Tuominen *et al.*, 2003; Wallace and Williams, 2001). The Cyprus national standard was CYS244, the Hellenic national standard was ELOT1416 (These standards were withdrawn in 2007), and the international standard is ISO 22000.

2.3.1 Food Safety Legislation in Cyprus

As mentioned previously, the HACCP system was first developed in the United States in the early 60s for the production of microbiologically-safe foods for use in NASA space flights. The system was first introduced in the European Union legislation in 1993 with each of the state members having their own legal structures. This produced significant challenges within the European Union. To overcome the problems aroused and incorporate HACCP into the legal system of all member states into the legal systems, the European Commission produced four directives, three ‘vertical’ directives for specific foodstuffs and the ‘horizontal’ directive for general foodstuffs DIR 93/43/EEC (EUC, 1993; Ropkins and Beck, 2000; Untermann, 1999).

The harmonization of the Cyprus legislation with the European legislation on HACCP took place through 2004 when Cyprus entered the EU. Before 2004 Cyprus had its own legislation on food hygiene which was partially in line with harmonization to the EU Hygiene directive 93/43/EEC. This Directive obligates that all enterprises that prepare, store, transfer, distribute, or allocate food must apply a HACCP system. The Cyprus national legislation before 1996 included only the five principles of HACCP. In 1996 with the new regulation “The Food (Control and Sale) law of 1996” (Ministry of Health, Health Services, 1996) the additional two principles (principles 6 and 7) on the documentation of the system were included. The legislation that rules HACCP system in Cyprus today is the same as the European legislation. With regard to HACCP, Regulation (EC) No 852/2004 applies.

More specifically, according to the Public Health Services of the Ministry of Health in Cyprus all food enterprises are obligated to apply and observe permanent procedures that are developed and implemented according to the principles of HACCP system for food safety. Complexity of the implementation of the system is related to the nature and the size of the enterprise. What is more, the application of this system must always be documented by keeping the necessary records. According to regulation 852/2004 of the European Union HACCP should not be implemented in primary food production for private use, or in domestic production, handling and storage of food for private consumption. However, all other food premises must implement such a system.

2.3.1.1 Flexibility of the Implementation of HACCP

The HACCP concept allows a flexible implementation of HACCP principles thus ensuring application in all circumstances including small and medium food businesses.

As stated in Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs, Recital 15, sufficient flexibility of HACCP requirements should be provided in all cases including small businesses. It must be recognized by government authorities that it is not possible for some food enterprises to fulfill all HACCP requirements, and some of them can be replaced by GHPs. What is more, flexibility should be provided for the retention of documentation in the small businesses. This way many burdens can be avoided without compromising food safety.

The same Regulation (Recital 16) states the importance of flexibility to enable the continued use of the traditional methods in all stages of the production. Again, this flexibility should not compromise food safety.

2.3.2 Prerequisite Programs of HACCP

HACCP is a part of a larger system of control procedures and can not stand alone. The implementation of HACCP depends on the people who operate and develop it and the PRPs.

PRPs provide the foundation for HACCP in an overall food safety management program. PRPs are those practices that are needed before and during the implementation of HACCP otherwise the system will not be functional (Tuominen *et al.*, 2003; WHO, 1998). The PRPs needed include GMP, GHPs, SOPs, SSOPs, and GAPs (FSRIO, 2005; Tuominen *et. al.*, 2003; Wallace and Williams, 2001). These practices are essential before HACCP implementation and form the foundation of the HACCP plan (Bas *et. al.*, 2006; Tuominen *et. al.*, 2003). The GMP and GHP provide the basic environmental and operating conditions for the production of safe food. They cover the general principles of hygienic food handling which apply universally in all food premises. The HACCP plan, which is process and premises specific, is superimposed on these practices.

GMPs are used in the food industry for the production of quality and safe products (Bender, 2005; Griffiths, 2001). A GMP programme may cover (NACMF, 1997)

- **Established Design and Facilities**: Location and structure of processing plant needs to be considered. Suitable facilities must exist for humidity and temperature control. Measures should exist for pest control.

- **Maintenance and Sanitation:** Existence of work instructions and procedures for efficient practices of cleaning, pest control and management.

- **Personal Hygiene:** Maintain an appropriate level of personal cleanliness and guidelines for personal hygiene.

- **Training:** Food handlers should be trained in the operations with which they are working and should be supervised by trained supervisors.

- **Transportation:** Measures should be taken for preventing contamination of commodities (storage under specific humidity levels, etc.). Containers used for transportation must be maintained in good condition and be easy to clean.

The GHP consists of all general practices regarding the conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain. GHP includes, among others, planned training courses and medical examinations, washing, disinfecting, and maintenance of hygiene rooms. After implementation and elaboration of GHP/GMP, the next logical step is development and implementation of a HACCP system. At this step specific CCPs are developed which relate to the precut handles in the premises.

2.3.3 National Standards: CYS244 / ELOT 1416:2000

Until 2007 the Greek HACCP national standard was ΕΛΟΤ 1416 and the Cyprus national standard was CYS244 that was basically the same. The role of the national standard CYS244 was to specify the requirements for a food safety management system that a food enterprise needed to demonstrate. These standards described the basic requirements of a food safety management system, based on the HACCP principles. These standards were applied by all enterprises that deal with the production, preparation, packaging, storage, transfer, and delivery of food products and also the suppliers of raw material as well as the restaurants. The existence of these national standards was necessary as no other international standard was available. In 2007 ELOT 1416:2000 and CYS244 were replaced by the new international standard ISO 22000:2005. During this research both national and international standards were used. National standard CYS244 was used until its withdrawal in 2006. A year of adaptation was allowed for the enterprises to implement ISO 22000.

In what follows the HACCP requirements are explained based on the national standard CYS244.

Management Responsibility

The management of the enterprise is responsible for the identification and evaluation of the hazards related to the food safety. The management has the obligation of ensuring a food safety policy according to the goals of the enterprise, the clients' requirements, and the legislation.

All problems related to products, procedures and the system have to be recorded and corrective actions taken. The coordinator of the HACCP system ensures the implementation and maintenance of the system and the co-ordination of the HACCP team. At the same time he/she reports to the administration. The HACCP team is responsible for the implementation and maintenance of the system. The enterprise has to provide the appropriate training to the employees involved in the implementation of the system. The administration has to re-examine the effectiveness of the system based on the food safety policy of the enterprise.

System Requirements

In general, PRPs are necessary for the correct application of HACCP. The HACCP system includes identification of the hazards, CCPs, critical limits, preventive and corrective actions, and documentation. The enterprise has to follow specific procedures for the control (audit) of the records and the database of the system. This control must ensure that only the proper records are available and any invalid or old records are not used by mistake.

HACCP Planning

In order to develop a HACCP plan the following steps are required:

1. Description of all raw materials and products and any information concerning their chemical, biological and physical characteristics (origin, life span, delivery conditions, packaging, and transfer and storage conditions) have to be available.

2. The possible users and consumers of the products have to be identified and a description of the expected use, relative to the storage, preparation and serving, has to be available.

Once the details of the product have been clarified, the seven principles of HACCP can be followed to create a HACCP plan. The HACCP team must develop an accurate flow diagram. This flow diagram must address all aspects of the process which are under the control of the facility. It should be a simple block diagram that is easily understood by all members involved in the system. All hazards biological, chemical, and physical have to be identified and analyzed based on the risk and the possibility of occurrence. Preventive action should exist for each hazard that requires control. An important step is to determine the CCPs in the process. Once the CCPs have been determined, a critical limit (amount of acceptable deviation) has to be established for each CCP. Corrective actions have to be taken for each CCP when observation shows that a CCP deviates from the critical limit.

Documentation of the HACCP System

Records for the HACCP system must be kept to document its usage. All non-conformity products that have been produced during a deviation from a critical limit have to be subjected to corrective action in order not to be consumed by mistake. The corrective action may consist of rejecting the product but in some cases reprocessing may make the product safe for consumption. An appropriate corrective action must be identified at each CCP and will be specific to the product and process.

Observance of HACCP

The HACCP team has to be informed regarding new products, changes in raw materials, equipment and production systems, the plant, cleaning and sanitation programmes, the legislation and any other changes that may affect the food safety system.

2.3.4 Comparison of HACCP and ISO 9001

The International Organization for Standardization (ISO) began operations on the 23 of February 1947 in Geneva, Switzerland, with the objective "to facilitate the international coordination and unification of industrial standards". The ISO 9000 standards series constitutes a complete and global system by which any enterprise or organization can optimize the quality of its operations and products. Whereas most standards concern the characteristics of raw materials and of their final products, the ISO 9000 series deals with the management of the functions of the departments inside an enterprise. By meeting these standards, the enterprise accomplishes a constant quality of the products and services that provides and ensures the customer satisfaction. ISO 9000 series includes (Ioannou, 1997):

- ISO 9000:2005 Quality management system – basic principles and glossary
- ISO 9001:2000 Quality management systems – Requirements
- ISO 9004:2009 Quality management systems - Guidelines for performance improvements

In particular, the ISO 9001 deals with quality management systems of an enterprise and more specifically with the correct organization of its functions that have to do with quality. The application of ISO 9001 can: (a) reduce defective products or deficient services, (b) specify the policy and the objectives for the quality that are going to be applied, (c) identify the needs and requirements of the customers and increase their satisfaction, (d) reduce the service time, and (e) improve the quality of the products and the performance of the quality system.

On the other hand, as mentioned before, HACCP deals only with hygiene and safety of the foods by identifying the hazards, rather than consistent quality as specified by ISO 9001. It must be stressed that the HACCP system and ISO 9001 constitute a complete system due to the fact that the operation principles of both systems are similar. The operation of both these systems achieves quality, hygiene and safety of the products. Table 2.1 briefly presents the main advantages of both systems (Motarjemi and Schothorst, 1999).

ISO 9001:2000	HACCP
▪ Profit improvement (productivity gains, cost reduction, reducing waste, improving staff motivation) ▪ Process improvements (elimination of procedural problems, better management control, improving customer service, improving efficiency, aiding induction of new staff) ▪ Marketing benefits (gaining new customers and keeping existing customers, increasing market share, improve customer satisfaction, increasing growth in sales) ▪ Reduction of barriers to international markets	▪ The system overcomes many of the limitations of the traditional approaches (high cost, time, limitations of "snap-shot" inspection) ▪ Identification and control of all reasonably expected hazards ▪ Capable of accommodating changes introduced, such as progress in equipment design, improvements in processing procedures and technological developments related to the product ▪ Helps to target or manage resources to the most critical part of the food operation ▪ Improvement in the relationship between food processors and food inspectors and food processors and consumers ▪ Promotion of international trade by equalizing food safety control systems everywhere in the world ▪ Applicable to the whole food chain, from the production of raw materials to the end-product ▪ Available documentation facilitates the inspection activities of food inspectors

Table 2-1 Advantages of HACCP and ISO 9001:2000

2.4 International Standard ISO 22000:2005 Food Safety Management System

The ISO 22000:2005 standard was developed by the ISO technical committee ISO/TC 34 (Technical Committee 34, Agricultural Food Products) and launched in 2005. It combines the issues of quality and safety. ISO 22000 is a generic food safety management system standard that defines a set of requirements for the food safety that can be applied by all organizations in the food industry. The ISO 22000 standard has been well received by the food industry and has become a global standard. The system's flexibility enables a tailor-made approach to food safety applicable to all segments of the food chain including primary producers, processors, manufacturers, food service providers, and product suppliers. The standard ensures food safety along the food chain by combining key elements. These include

- Interactive communication along the food chain to ensure that all food safety hazards are identified and controlled,
- System management relying on a structured management system based on relevant parts of ISO 9001,
- Hazard Control that combines the HACCP principles and application steps developed by the *Codex Alimentarius*.

The benefits of the implementation of the standard for an organization include, among others, a valid basis for taking decisions, systematic management of PRPs, increased due diligence, saving resources by reducing overlapping system audits, more efficient and dynamic control of food safety hazards, optimization of resources, improved documentation, better planning and less post-process verifications (Færgemand, 2008).

ISO 22000:2005[4] series is supported by a complete set of standards including, among other standards, the technical specification ISO/TS 22003:2005 concerning audit and certification, ISO/TS 22004:2005 specification for applying food safety, and ISO 22005:2007 on traceability in the feed and food chain.

Food producers from various parts of the chain around the globe have adopted ISO 22000 as a food safety standard. An informal survey conducted by experts responsible for having developed the ISO 22000 series standards reveals that the ISO 22000 standard is being implemented by at least 1152 companies in 72 countries (Chamber, 2008). Among them are some major companies including France's Group Danone, Kraft Foods Inc., one of the world's largest food and beverage companies, and VanDrie Group - a world leading veal producer (Swinkels, 2008; Tranchard, 2008, Overbosch *et al.*, 2008). However, many SMEs do not yet apply the standard. As mentioned before, SMEs must overcome barriers to implement such a complicated form of the system. It is more useful and achievable to have a simplified form of the system. ISO 22000 is useful and necessary for large enterprises that can employ personnel specialized in the application of the system, and that have the capital for making the necessary changes and thus satisfy the system. For SMEs that don't have

[4] All standards are available for purchase from www.iso.org

the above, application of such a system is a disadvantage rather an advantage, since it will create many problems.

For SMEs to have in place a system based on ISO 22000 they must spend a lot of time and money not only in applying the system but also for its verification and maintenance. In order for an enterprise that has in place ISO 22000 to keep its certificate valid an annual third party audit is required. In Cyprus such an audit from an accredited certification body varies in cost from €1700 to €2500 per year (Vasilliou, 2003b) depending on the size and the production of the enterprise. On the other hand enterprises that apply the requirement of legislation based on Regulation (EC) No 852/2004 do not need third party audit since the audit relies on the member states own inspection service. In Cyprus inspections from the Environmental Health Officers (EHOs) of the sanitary services of the Ministry of Health are free. EHOs can not give a HACCP certificate like the certification bodies, but this is not required for compliance with article 5 of Regulation (EC) no 852/2004. The implementations of standards are not legally required. The role of the standards is to help the food enterprises to implement systems that consistently provide safe products.

HACCP itself requires verification which doesn’t necessarily require a third party audit. Verification activities can be internal, conducted by the HACCP team; or external, conducted by a third party (Sperber, 1998). Principles 6 and 7 of HACCP system requires verification, validation and review of the HACCP once it is operational. Verification is the determination that the HACCP system is in compliance with the HACCP plan. Validation is the method to verify the effectiveness of the

HACCP system. Review includes the procedures to verify and validate the HACCP system (Griffiths, 2001). Periodic verification of the HACCP system should be conducted internally in the enterprise. Verification of the system should be managed by the food business. Food business operators can take the responsibility for verification, validation and review of the system. Training of the HACCP team members is necessary, as there is a direct relation between the ability to validate the system and the level of knowledge (Griffiths, 2001). In some cases when personnel were well educated internal audits can be done to verify the system. This is more common in big enterprises where there are a number of personnel and different departments. One exception occurred during the research concerning a small confectionery whose owner was a chemist and could conduct internal audits for the verification of the system of his enterprise. Such cases are very rare in SMEs, and most of them need an external audit performed by consultants.

3 RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research methodology and outlines the research problem and objectives of the study. It gives the rationale of the approach adopted to answer the research question. For the analysis and investigation primary and secondary data collection methods have been used. This chapter describes the design of the different documents that have been used to gather the data from companies including audit checklist, questionnaire, and the tests.

3.2 Research Problem and Objectives

As mentioned in the introductory chapter, with the imposition of HACCP in the food industry in Cyprus, SMEs encountered a variety of problems. Cyprus economy is dominated by SMEs constituting 99.9% of all enterprises. The majority of these SMEs (95%) employ less than 10 persons (Ministry of Commerce, Industry and Tourism, 2005). The four classes of enterprises by activity under study, restaurants, fast foods, bakeries and butcheries are 3770 (Statistical Service of Cyprus, 2005). The main objective of the study is to assess whether the implementation of food management systems, especially HACCP, improves the hygiene in food premises in SMEs in

Cyprus. This is achieved by investigating the food safety levels before, during and after the implementation. The research also assessed the degree of complexity of these implementations. Furthermore, the study investigates whether there are benefits in having such a system in place, and if so, whether the investments required for successful implementation justify the benefits.

3.3 Methodology Design

3.3.1 Study Population

The research was carried out from October 2005 to April 2008. The population of this research consisted of SMEs located in the island of Cyprus. For sample size determination Cochran's formula (Cochran, 1977) was used with a 95% confidence level and a ±10% acceptable level yielding a size of 45. A sample of 50 food SMEs was selected for the study. The information gathered included names, addresses, size of the company, and status of the company. Due to the researcher's employment as a consultant in the implementation of HACCP system the sample consisted of SMEs from the researcher's background. These SMEs came forward out of necessity in applying the HACCP system in order to comply with the requirements of the European regulation. The Minister of Commerce, Industry and Tourism in Cyprus stated that any food enterprise that does not comply with the European Regulation will be closed down (Nicolaou, 2003). The sample enterprises were registered as SMEs in the Cyprus Chamber of Commerce and Industry (KEBE) Dictionary (1998), and Ministry of Tourism, Industry and Commerce.

The first approach to the SMEs was through a visit in their premises, when they signed an offer for consulting services concerning the implementation of a HACCP system. The offer included consulting services starting with diagnostic report, conducting a HACCP plan study, and training to both employees and managers on HACCP implementation. The researcher was responsible for the implementation of the food management systems in the 50 SMEs, and the certification of these enterprises from a certification body. The participating enterprises were informed of the research in the first visit and all volunteered to join the project until its completion. A sample of fifty was chosen as they were the full workload/responsibility of the one consultant/researcher. This selection process eliminated any variation that might have arisen had more than one person become involved in the development of the HACCP plans or in the data collection.

The study population consisted of restaurants, fast food enterprises, catering, traditional taverns, confectionaries, butcheries, and bakeries. Most of them were situated in the capital of Cyprus, Nicosia, and some of them were in other towns (Pafos and Limassol). The majority of the enterprises were family owned that were transferred from generation to generation and have been in the business for a long time. The food sector in Cyprus is stable because of this family inheritance. The smallest enterprise in the sample consisted of 2 employees and the largest consisted of 21 employees. According to the Statistical Service of Cyprus (Statistical Service of Cyprus, 2005) SMEs in Cyprus consist of four categories according to employees' number, from 0-9, 10-49, 50-249, and over 250 employees. From these, 95% fall in the first category. Thus, the sample is representative.

3.4 Ethical Consideration

All involved parties that participated in the study were informed of the research conducted as well as of the use of the data and the information that had provided. At a later stage the CYS, was also informed. All the enterprises participating were co-operative providing all the records and data needed for the research. None of the enterprises participating had a HACCP plan in place at the start of the project.

During the study, there was collaboration with the EHOs and health inspectors from the department of Public Health of the Ministry of Health, and the Ministry of Tourism, Industry and Commerce. All the audit results provided by the government officers, as well as the laboratory results, enterprises recipes, audit results, and certification observations, remained strictly confidential. No information was provided from one enterprise to the other.

3.5 Study Design

The study investigates the different levels of the implementation of HACCP, starting from the beginning before any implementation of the system, until the end with the full implementation of the system and the companies' further effort to comply with the ISO 22000 standard.

The whole implementation process was split into different levels to identify which was the most appropriate and successful form of the system that SMEs could easily implement, and what effects could be identified at that level. Based on regulation (EC)

No 852/2004 the level of complexity of the system should be different based on the enterprise size and activity. The regulation allows the HACCP based procedures to be implemented with flexibility, to ensure that they can be applied in all situations (legislation 852). The question for the SMEs is what the acceptable level of flexibility is that they can apply. The research has been split into different levels to clarify to what extent can flexibility, with regard to the implementation on standards, be applied. In particular, in SMEs there is a complexity limit of the system that can be adopted. If this limit is exceeded then the results are negative. To identify this limit the study was split in eight levels as shown in table 3.1 below. The table lists:

(i) under each of the levels the visits carried out, and the activities carried out at each visit;

(ii) the methods used at each visit, and the data analysis methods used;

(iii) the parts of the thesis in which the work is discussed.

Level	Visit	Time between visits (months)	Activity	Person conducting the activity	Evaluation	Method	Validation of method	Data analysis / Determination of significance	Chapter reference	Appendix
1	1	0,5	Informative meeting: information regarding the procedures of the implementation of HACCP system and the research.	Researcher and consultancy office						
	2	0,5	Diagnostic audit and indications for changes / Data collection	Researcher	Hygiene Practices	Audit 1	Audit validation (Independent Auditor)	• Kolmogorov-Smirnov and Shapiro-Wilks tests • Friedman´s test • Wilcoxon Rank Sum test	3.7.1 4.3	A1
					Cleaning / Food safety	Surface / hand swab tests. Food Analyses 1		• Kolmogorov-Smirnov and Shapiro-Wilks tests • Kruskal-Wallis test • Mann-Whitney test	3.7.3 4.5	B1/B2/B3
					Knowledge	Test 1		• Friedman´s test • Wilcoxon Rank Sum test	3.7.4 4.6	C1
2	3	2	Training on PRPs	Researcher						
	4	2	Training on PRPs	Researcher						
	5	1,5	Training on PRPs	Researcher						
	6	0,5	Data collection	Researcher and accredited laboratories	Hygiene Practices	Audit 2		• Kolmogorov-Smirnov and Shapiro-Wilks tests • Friedman´s test • Wilcoxon Rank Sum test	3.7.1	A1
					Cleaning / Food safety	Surface / hand swab tests / Food analyses 2		• Kolmogorov-Smirnov and Shapiro-Wilks tests • Kruskal-Wallis test • Mann-Whitney test	3.7.3 4.5	B1/B2/B3/ B4
					Knowledge	Test 2		• Friedman´s test • Wilcoxon Rank Sum test	3.7.4 4.6	C2
					Attitude	Questionnaire 1	Cronbach's alpha	• Friedman´s test • Wilcoxon Rank Sum test	3.7.2 4.6	D1

3	7	2	Coaching on HACCP principals / enterprises provided with guidelines	Researcher						
	8	1	Coaching and answering questions on HACCP principles	Researcher						
4	9	2	More rigorous overview of HACCP principles	Researcher						
	10	2	Development of HACCP plan based on HACCP principles according to Codex Alimentarious / enterprises provided with guidelines	Researcher and HACCP team						
	11	1,5	Presentation and explanation of HACCP plan to personnel and its implementation. Assistance on legislation concerning HACCP plan	Researcher and HACCP team						
	12	0,5	Data collection	Researcher and accredited laboratories	Hygiene Practices	Audit 3		• Kolmogorov-Smirnov and Shapiro-Wilks tests • Friedman´s test • Wilcoxon Rank Sum test	3.7.1 4.3	A1
					Cleaning / Food safety	Surface / hand swab tests / Food analyses 3		• Kolmogorov-Smirnov and Shapiro-Wilks tests • Kruskal-Wallis test • Mann-Whitney test	3.7.3 4.5	B1/B2/B3/ B4
					Attitude	Questionnaire 2		• Friedman´s test • Wilcoxon Rank Sum test	3.7.2 4.4	D1
5	13	2	Recommendations and assistance on barriers during the implementation of HACCP plan	Researcher						
	14	1	Advice on record keeping	Researcher						

6	15	2	Training on ISO 9001 and management system	Researcher						
	16	2	Training on CYS244 standard	Researcher						
	17	1,5	Training and guidelines on the application of CYS244 standard	Researcher						
	18	0,5	Data collection	Researcher and accredited laboratories	Hygiene practices	Audit 4		• Kolmogorov-Smirnov and Shapiro-Wilks tests • Friedman's test • Wilcoxon Rank Sum test	3.7.1 4.3	A1
					Cleaning / Food safety	Surface / hand swab tests / Food analyses 4		• Kolmogorov-Smirnov and Shapiro-Wilks tests • Kruskal-Wallis test • Mann-Whitney test	3.7.3 4.5	B1/B2/B3/ B4
					Knowledge	Test 3		• Friedman's test • Wilcoxon Rank Sum test	3.7.4 4.6	C3
					Attitude	Questionnaire 3		• Friedman's test • Wilcoxon Rank Sum test	3.7.2 4.4	D1
7	19	1	Certification	Certification Body						
	20	2	Presentation and explanation of ISO 22000 and its application	Researcher						
8	21		Coaching on the changes of the system according to ISO22000. Advice on record keeping for the application of ISO 22000	Researcher						
	22	2	Data collection	Researcher and accredited laboratories	Hygiene Practices	Audit 5		• Kolmogorov-Smirnov and Shapiro-Wilks tests • Friedman's test • Wilcoxon Rank Sum test	3.7.1 4.3	A1
					Cleaning / Food safety	Surface / hand swab tests / Food analyses 5		• Kolmogorov-Smirnov and Shapiro-Wilks tests • Kruskal-Wallis test • Mann-Whitney test	3.7.3 4.5	B1/B2/B3/ B4
					Attitude	Questionnaire 4		• Friedman's test • Wilcoxon Rank Sum test	3.7.2 4.4	D1
					Cost	Cost collection		• Linear Regression Analysis • ANOVA	3.7.5 4.7	

Table 3-1 Detailed listing of the methods used in the various levels

In what follows, the eight levels are described in detail.

- **LEVEL 1:** Before any intervention, when the companies decided to implement a food safety management system. Here a diagnostic audit, based on the requirements of the legislation (EC) No. 852/2004 and PRPs, was designed and conducted by the researcher. This provided baseline data and indicated the infrastructure changes that the company should do as a part of the PRPs to be able to implement HACCP.

- **LEVEL 2**: The enterprises apply the PRPs that provide the foundation for effective HACCP implementation. This package of food hygiene measures included: infrastructural and equipment requirements, raw material requirements, food waste handling, pest control procedures, cleaning and disinfection procedures, analysis of the quality of water, personal hygiene procedures, and training of all personnel involved in the system implementation.

- **LEVEL 3**: Enterprises go further, to the application of simple forms of guides for food hygiene. An introduction on HACCP principles was conducted. The researcher assists the premises on food hygiene guides and on HACCP principles. These guides give advice on simplified implementation of HACCP requirements and provide sufficient flexibility in small businesses. Despite their simplicity they provide an efficient way to overcome difficulties that businesses may encounter in implementing a detailed HACCP system. They are designed to help food businesses to control hazards by describing in a practical and simple way the methods to control hazards without entering into too many details.

- **LEVEL 4**: In level 4 the HACCP system was implemented. The researcher guided and assisted the enterprises to apply the seven principles of HACCP, and at the same time to fulfill the requirements of the legislation. HACCP was separately applied to each enterprise according to their specific operation. The fifty enterprises were separated in different groups based on their activities. The four groups were (a) Restaurants, (b) Fast Foods, (c) Bakeries, (d) Butcheries as described in chapter 5. The researcher ensured that all groups understood the procedures of the system and the HACCP principles. The system applied was flexible and took into consideration the nature and the size of the enterprise. On this level the HACCP system consisted of the following seven principles (see section 2.2.3 [HACCP Principles]): (a) identification hazards (hazard analysis), (b) identification of CCPs, (c) establishment of critical limits at each CCP, (d) establishment and implementation of effective monitoring procedures at CCPs, (e) establishment of corrective actions, (f) establishment of procedures to verify that the measures mentioned above are working effectively, (g) and establishment of documents and records commensurate with the nature and size of the enterprise. On this level the use of a diary or a checklist was introduced as a suitable way of record keeping. The researcher together with each enterprise created these diaries and check lists according to their specific operation using as guidance the seven principles of HACCP and the requirements of the legislation.

- **LEVEL 5**: Level 5 was a coaching level on record keeping. Enterprises applied the system in a more complicated way by entering into more details regarding the nature of the hazards, together with a more formal identification of CCPs. The enterprises covered all significant hazards and clearly defined in detail procedures to control these hazards. More complicated corrective actions were recommended by the researcher in case of a problem. In addition methods to control food contamination were initiated. A more extensive HACCP-related record keeping was presented and applied by the researcher. The HACCP plan was specific to the business and each was designed by the HACCP team through the guidance of the researcher as explained in section 3.6.2. The size of HACCP team ranged from 2 up to 8.

- **LEVEL 6**: The enterprises, with the guidance of the researcher, moved on to the application either of the Cyprus national standard (CYS244), or the Greek national standard (ELOT 1416) that were the same. Premises had the opportunities to ask questions relating to their business and the application of the standards. These standards were a combination of the requirements of the ISO 9001 and a HACCP plan. Based on the ISO 9001 requirements, enterprises had to keep records concerning both the food safety and the organization and management of the company. Since many documents and records had been added due to the application of the standards, the HACCP system become more bureaucratic. The need for a record keeping was extended beyond to what was essential with regard to food safety as the enterprises had to keep management records as well. The system that was created based on the national standards was a system which required a yearly audit from an accredited certification body providing to the company a HACCP certificate.

- **LEVEL 7**: The researcher prepared the enterprises fully for the certification according to the CYS244/ΕΛΟΤ1416 standards providing a pre audit.

- **LEVEL 8:** The enterprises transferred from the withdrawn national standards to the application of the international standard ISO 22000. ISO 22000 was approved by the Board of CYS in 2005. A period of two years from 2005 to 2007 was given to the enterprises in order to comply with the new standard. This standard required a combination of an interactive communication system, a management system and a HACCP system. Enterprises with the help of the researcher had to incorporate their HACCP systems into the new system required by the new standard ISO22000.

3.5.1 Data Collection

The researcher conducted a survey as described in this section in each critical level (1, 2, 4, 6, and 8) in order to assess the improvement of the enterprise and compare the food hygiene levels, the knowledge, the attitude, the cleaning and disinfection, and the food safety in the different levels. Critical levels are those levels where a company performed or completed significant changes, i.e. transition from PRPs to HACCP plan, from HACCP plan to CYS244, and from CYS244 to ISO 22000. The evaluations were conducted through audit tests, questionnaires, and environmental and food sampling. The data were collected in a 30 months period by conducting a series of observations and interviews (table 3.1). This involved routine visits to all the premises at appropriate intervals. Premises received 22 visits each over the 30 month of the study period. Appendix F presents a sample chronology for a specific enterprise giving the activities performed in each visit.

In order for a company to get from one level to the next it had to upgrade the implementation of the system starting from the implementation of PRPs during the first two levels, the application of HACCP plan during the 3rd and 4th levels, the application of CYS244 during the 5th and 6th levels and an upgrade to the ISO22000 on level 8. At each level the researcher provided guidance and assistance to the enterprise. In order for an SME to move from one level to the other evaluations of hygiene practices, cleaning, food safety and attitude were performed by the researcher and accredited laboratories.

LEVEL 1, VISITS 1st and 2nd: The 1st visit took place as soon as the enterprises signed the consultation agreement. During this visit companies were informed of the procedures to be followed to help them implement HACCP. The researcher prepared and provided a time schedule of the visits (Appendix F) and the training to the enterprises. During the 2nd visit, fifteen days after the 1st visit, a diagnostic audit was conducted and the results were given to the companies to enable them to perform all necessary changes required by the PRPs. A baseline evaluation was conducted in Hygiene Practices, Cleaning and Food Safety, and Knowledge. The first evaluation in Hygiene Practices was conducted through audit1 in level 1 (Appendix A1) prepared by the researcher as described in section 3.7.1. One audit checklist was prepared and used over the five evaluations (table 3.1). The first evaluation in Cleaning and Food Safety was conducted through environmental and food sampling (Appendix B) from accredited laboratories as described in section 3.7.3. The first evaluation in knowledge was conducted through Test1 (Appendix C1) as described in 3.7.4. Three different tests were prepared and used in levels 1, 2, and 6. The audit and the test were designed by the researcher based on other auditing and testing material used by government officials as described in section 3.7.1.1, and 3.7.4. In order for an enterprise to move into level 2 the researcher provided advice regarding infrastructure changes in order to prepare the enterprises to enter level 2.

LEVEL 2, VISITS 3rd, 4th, 5th, and 6th: The 3rd visit took place fifteen days after the 2nd visit (table 3.1). During this visit the training of the personnel (all employees of each enterprise) was initiated by the researcher and the enterprises started the application of the PRPs. Staff was left with the training package to look at it and to prepare for the 4th visit. The 4th visit took place two months later during which a coaching session took place through a seminar. Assistance was given by the researcher in the application of PRPs through the seminar covering the GMP and GHP as described in section 2.3.2. The seminar finished two months later during the 5th visit. The training course was designed by the researcher after a study on other trainings provided by the consultancy offices of the researcher's working background. The training consisted of three sessions run by the researcher each with duration of eight hours. The first two sessions were theoretical lectures on the application of PRPs and the third session was on the job training. The 6th visit took place a month and a half later and was a data collection visit. During this visit interviews with the owners and the managers were conducted by the researcher. One questionnaire (Appendix D1) was prepared by the researcher as described in section 3.7.2 and the same questionnaire was over the five evaluations. The first evaluation of the questionnaire (level 2) was completed by owners and managers to find out their experiences and their attitude to the application of the PRPs. Test2 (Appendix C2), designed by the researcher as described in section 3.7.4, was given to the personnel involved in the training at the end of the training sessions, in order to measure their knowledge and to see whether there was an improvement after the training. The tests were marked by the researcher according to the mark scale described in 3.7.4. An evaluation in environmental and food sampling was conducted by an accredited laboratory to assess any changes in cleaning and food safety due to the PRPs implementation. Finally, Audit2 was conducted in order to assess any changes to hygiene practices.

LEVEL 3, VISITS 7th and 8th: These two visits served mostly as coaching sessions. The 7th visit took place fifteen days after the 6th during which assistance was provided on the HACCP principles according to the guides of *Codex Alimentarius*. Appropriate guides on the explanation and analysis of the HACCP principles were provided to the enterprises. The researcher proposed recommendations on how to use the guides. The 8th visit took place two month later in order to check the progress of the enterprises and to answer any questions that they came across during the study of the guides.

LEVEL 4, VISITS 9th, 10th, 11th, and 12th: In level 4 there was implementation of HACCP system and the seven principles. The 9th visit took place one month after the 8th. During this visit the researcher provided the premises with a more rigorous overview of the HACCP system. The 10th visit took place two months later during which a HACCP plan (Appendix E1) was developed for each of the premises according to the *Codex Alimentarius* guidelines. The researcher provided consultation to the HACCP team of each enterprise on the verification of the products and the flow diagrams (Appendix E2) according to the enterprise production. The enterprises had a two month interval until the 11th visit to look at the flow diagrams, cross reference with their every day production, and consider any changes. During the 11th visit the HACCP plan was finalized and presented by the researcher and the HACCP team to the personnel involved in the system and an explanation of its application was provided. Also, during this visit the researcher provided assistance on the requirements of the food legislation concerning the HACCP plan and its implementation. The 12th visit took place one and a half months later and involved data collection. Interviews with the owners and managers were conducted and the second evaluation of the questionnaire was performed to find the personnel's attitude towards the HACCP plan, the application of the seven principles of the HACCP system, and the application of the legislation. The third evaluation (environmental and food sampling) was conducted by an accredited laboratory in order to assess any changes in cleaning and food safety due to the HACCP system (HACCP plan and seven principles) implementation. Audit3 was also conducted in order to assess any changes to hygiene practices.

LEVEL 5, VISITS 13th and 14th: Level 5 was a coaching level on record keeping and any problems and barriers an enterprise faced during the implementation of the HACCP system. These two visits were coaching sessions. During the 13th visit, that took place half a month after the 12th visit, recommendations were provided by the researcher to the premises regarding the barriers and the problems that they had faced during the implementation of the system. The researcher also provided guidelines to the enterprises advising them on how to carry on. Two months later during the 14th visit the enterprises were introduced into more detailed procedures regarding the system and had been advised on record keeping.

LEVEL 6, VISITS 15th, 16th, 17th, and 18th: During these visits the enterprises started the application of the national standard CYS244. During the 15th visit, that took place a month after the 14th, training on the standard started and continued over a 4 months period until the 17th visit (table 3.1). The training course was designed by the researcher based on material by the researcher's background and consisted of three sessions eight hours each, all presented by the researcher. All three sessions were theoretical rather than on the job training. After completion of the training, Test3 was given to the personnel involved in the training to measure their knowledge.

The first session was presented during the 15th visit and contained an introduction to the management system and the ISO9001. The second was presented during the 16th visit where all the requirements of the national standard CYS244 were analyzed. The completion of the training was performed two month later with the 17th visit during which the third session was presented. This included guidelines on the application of the standard and on how the enterprises could combine CYS244 with HACCP system. The 18th visit, which was a data collection visit, took place after one and a half months (time was given to the enterprises to conform to the new changes). Test3 (Appendix C3) was given to the personnel participating to the training sessions in order to measure their knowledge and see whether or not there was any improvement after the training. Interviews with the owners/mangers were conducted to find out their impressions regarding the application of the CYS244 standard and their attitude towards the system. The third evaluation of the questionnaire was completed. The fourth evaluation (environmental and food sampling) was conducted by an accredited laboratory to assess any changes in cleaning and food safety due to the application of the standard. Finally, Audit4 was conducted in order to assess any changes to hygiene practices.

LEVEL 7, VISIT 19th: The 19th visit took place a month later, during which a third party audit was conducted by a certification body according to the national standard CYS244. The researcher was responsible to provide any verification regarding the system to the auditors. If no major non-conformities were identified the company was given a HACCP certificate after a third party audit from a certification body. It was important for a company to get the HACCP certificate as this was a reward for the effort in implementing the system. In addition, with a HACCP certificate the danger for the company to close down from government inspectors was eliminated.

LEVEL 8, VISITS 20th, 21st, and 22nd: The 20th visit was performed 1 month after the 19th visit. This was an informative visit on the new international food standard ISO 22000. During the visit the ISO 22000 standard was presented by the researcher to the managers together with an explanation on how to apply it in their business and on how to replace the existing national standard. The 21st visit took place two months later and was a coaching visit. During the visit recommendations were given regarding the changes of the system according to ISO22000. Guidelines were also provided on record keeping and advices were provided on the barriers that the enterprises face during the implementation of ISO 22000. The 22nd visit was performed two months later and it was a data collection visit. Interviews with owners/managers were conducted to find their attitude towards the application of ISO22000. The fourth evaluation of the questionnaire was performed and the questionnaire was completed. The fifth and last evaluation (environmental and food sampling) was conducted by an accredited laboratory to assess any changes in cleaning and food safety due to the application of the new international standard ISO 22000. Finally, Audit5 was performed in order to assess any changes to hygiene practices.

3.6 Development of PRPs, HACCP system and integration with standards

The development of the PRPs was conducted through a training during level 2 in the 3rd, 4th, and 5th visits. The national standard CYS244 was conducted through training sessions during the 6th level, visits 15, 16 and 17. The development of HACCP plan was conducted through coaching sessions with each enterprise during level 4 in the 10th visit (table 3.1).

3.6.1 PRP Prerequisite Programs

The PRPs were presented to the enterprises through a seminar designed by the researcher, based on the researcher's working background, on level 2, visits 3, 4, and 5 (table 3.1). The seminar contained GHP and GMP as described in 2.3.2 that had to be applied in order to establish a HACCP system and food hygiene requirements. The seminar consisted of three sessions. The first session discussed personal hygiene and training on the health of staff. The second session discussed infrastructural and equipment requirements and the safe handling of food (including cross-contamination). The third session contained food waste handling, pest control procedures and sanitation procedures (cleaning and disinfection), and on the job training on the GHP.

3.6.2 Development of a HACCP System

For each enterprise a specific HACCP system was designed by the researcher and the HACCP team according to its operation. The system was based on the *Codex Alimentarius* guidelines, and the requirements of legislation EC No(852) 2004. The HACCP system included the application of the seven principles. In each enterprise a HACCP team was formed, the size of which depended on the number of personnel of each enterprise (ranged from 0-5 people). For enterprises of less than 5 individuals a HACCP team was not formed; all personnel were involved in the implementation of the system. For enterprises of more than 5 individuals a HACCP team included a maximum of 5 persons. The scope of the HACCP plan (Appendix E1) was identified by the HACCP team. A HACCP plan was developed with the collaboration of the researcher and the enterprises' personnel involved in the implementation of the system. The HACCP plan was based on the description of the product, the identification of the intended use of the product, and the flow diagram of the production of each enterprise.

During the consultation an on-site confirmation of flow diagram and a listing of hazards and control measures were conducted by the researcher and the HACCP team.

After identification of the CCPs, critical limits at each CCP were set. Monitoring procedures were developed at each CCP as well as corrective actions and verification procedures. A sample HACCP plan can be found in Appendix E1. Documentation and record keeping forms were designed to assist the businesses to verify that the HACCP procedures are in place and are being maintained. Documentation included flow diagrams, hazard analysis, CCP determination, critical limit determination, and maintenance of the system. Records included CCP monitoring procedures, non-conformities and corrective actions, and verification procedures. A simple record keeping system was designed by the researcher and the HACCP team in order to be effective. It was integrated into existing operations of the enterprises and in most of the enterprises existing paperwork, such as delivery invoices. The HACCP system included the PRPs, the flow diagrams, the seven principles (HACCP plan included), definitions, and the record forms for the record keeping.

3.6.3 Integration with the Standards

The national standard CYS244 was presented to the enterprises through a seminar designed by the researcher based on the researcher's working background. The seminar consisted of three sessions on level 6, visits 15, 16, and 17 (table 3.1). The first session contained an introduction to the standards, including ISO9001:2005. The second session analyzed the requirements of CYS244, and the third session included guidelines for the application of CYS244. In level six the system was designed for each enterprise according to CYS244. After the withdrawal of CYS244 the system was adjusted with the new international standard ISO22000 in level 8 (table 3.1). According to ISO 22000 the system included four key elements: (1) involvement of the management team, which developed an overall policy, (2) communication both upstream and downstream, (3) the combination of the HACCP system (HACCP principles including the HACCP plan) with the PRPs, and (4) a management system. ISO 22000 relies on a structured management system based on relevant parts of ISO 9001. The system included an extensive documentation and record keeping.

3.7 Evaluation of the System at the Different Levels

Evaluations were conducted by the researcher and an accredited laboratory in the levels that considered critical for the implementation of the system. Critical levels are those levels where an enterprise performed or completed significant changes and at the end of each level an evaluation is performed, the results of which are compared to the previous evaluations. The critical levels are: level 1 (before any intervention), level 2 (after implementation of PRPs), level 4 (after implementation of the 7 principles of HACCP), level 6 (after implementation of the national standard CYS244), and level 8 (after implementation of the international standard ISO 22000). The purpose of these evaluations at each critical level was to give information concerning the hygiene practices, cleaning, food safety, knowledge and attitude during the implementation of the PRPs, HACCP system, CYS244 and ISO22000. Table 3.1 summarizes the evaluations that were used in each level and the method that had been used for each evaluation. In what follows a description of the selection of the four methods used (audit, questionnaire, tests, and environmental and food sampling) and the validation of each method is analysed.

3.7.1 Audit

As stated in the literature, audit is an important tool in assessing the HACCP plan and to ensure that it is up to date and follows the prerequisites and the seven principles (Souness, 2000; Sperber, 1997). With an audit one can verify and monitor if the system is working efficiently. According to ISO 9000:2000 (ISO, 2000) the definition of an audit is a systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which audit criteria are fulfilled. Azanza (2006) and Souness (2000) define a food safety audit as a documented activity used to evaluate and verify food handling practices and to evaluate whether a food safety management system has been followed effectively. As suggested in the literature, an audit should consider aspects such as storage and development of HACCP plans, equipment, structural characteristics, food production procedures etc. (Legnani *et al.*, 2004).

3.7.1.1 Selection of the Method

As observed in the literature, practises like temperature, time, personal hygiene and hand washing, and cross contamination are common to most businesses (Giampaoli *et. al.*, 2002a). All of these can be considered important in the food industry and for the reduction of food outbreaks.

After considering other sample audit checklists and with helpful advice by EHOs an audit checklist was generated by the researcher. Sample audit checklists included the audit checklist used by EHOs in Cyprus (Ministry of Health Cyprus, 2005), the official audit checklist used by the EFET in Greece (EFET, 2004), and the audit sheet used in the application of HACCP in Balti restaurants (Smith *et. al.*, 2004). Taking into consideration the parameters that had to be examined, and the objective of the study, that is to assess any differences to the hygiene practices due to the implementation of HACCP system, the final audit checklist consisted of the following parts: Part A: Building and Facilities, Part B: Cleaning and Disinfection, Part C: Production and Process Control, Part D: Performed Evaluations, and Part E: HACCP System Documentation. The full checklist is given as Appendix A1.

3.7.1.2 Structure of the Audit Checklist

The audit checklist was designed to measure changes to the level of hygiene practises of the enterprises over the different levels of the implementation of the system. The same audit checklist was used through the different levels of the evaluations (levels 1, 2, 4, 6 and 8). An improvement in hygiene practices would indicate a positive impact of the HACCP system to the enterprise. No improvement would indicate the system does not provide any change to the hygiene level of the enterprise. The questions of the audit checklist were designed to be answered by observation.

The audit checklist was designed in line with the requirements of the system in the different levels of the implementation. The audit checklist was developed considering (1) requirements of PRPs (building and facilities, equipment, cleaning and disinfection, personal hygiene, cross contamination, handling practices), (2) production and process control (temperature monitoring, product display, food storage) and (3) HACCP documentation and record keeping.

At the beginning of the audit checklist there was an informative question concerning details of the enterprise. Based on the section for the type of the enterprises the following subgroups were created according to their products: 1) Restaurants (include groups 1, 4 and 7), 2) Fast Foods (include groups 2, and 3), 3) Bakeries (include groups 5, and 8), and 4) Butcheries (include groups 6 and 9) (Appendix A1).

Part A comprised 27 questions covering 33 items. These questions are related to building design, the area around the building, and equipment. Part B comprised 20 items (18 questions) and is related to cleaning and disinfection, personal hygiene, and pest control. Part C comprised 14 questions. It is related to incoming products, storage and temperature, processing and production and product display. Part D comprised five items covering three fields; water analysis, environmental analysis (surface and hand analysis) and food analysis. Part E comprised 99 items concerning the implementation and documentation of the HACCP system. These items included the food safety policy, HACCP team, product description, flow diagram, the seven principles of the system, non-conformity products, traceability, GMP, pest control, training, and calibration.

The format used for the audit checklist consisted of two possible answers, YES and NO. This was the same for all parts. The YES reflected the items for which the establishment satisfied the requirements of the checklist. A NO answer reflected the items for which the establishment did not satisfy the requirements. For each YES answer 1 point was assigned and for each NO answer 0 point. The final score was achieved by adding all the points. The same audit checklist was used during the five evaluations that have been conducted in different levels of the implementation of the system (level 1: before any intervention, level 2: PRPs, level 4: HACCP system, level 6: CYS244, and level 8: ISO 22000). Each audit was conducted by the researcher and lasted approximately one and a half hours depending on the size of the enterprise. Each part of the audit evaluation was compared over the different levels.

3.7.1.3 Validation of the Method

In order to confirm that the audit sheet can be used by different auditors and still provide the same results, an independent auditor's results on 19 of the enterprises included in the survey have been used. The independent auditor was one of the researcher's colleagues. The scores from the audit validations performed by the two independent auditors were used to test for any significant differences. The total scores of the validations are converted into ranks (values are replaced by their rank when the data are sorted). Comparisons of mean rank measures were made between the two auditors' results using a Mann-Whitney non-parametric test (Gorder and Foreman, 2009).

The evaluations of the two auditors were performed in levels 1 and 2 during the 2nd and 6th visits. The Mann-Whitney *U* test evaluates whether the mean rank scores from both the researcher's audit and the independent auditor's audit in each part of the checklist in the two levels differ significantly from each other. The results of the tests are summarized in table 3.2. Actual calculations are available in Appendix A2. In all parts (A1-D1) of level 1 no statistically significant difference was found. The mean scores are very close to each other with a large *p*-value (>0.05) indicating high agreement between the two evaluations. No significant difference was also recorded on the audit parts (A2-E2) of level 2. The above indicate clearly the validity of the audit results.

Level	Audit Parts	Mean Rank Scores 1st auditor (n=19)	Means Rank Scores 2nd auditor (n=19)	p-value
1	A1	19,34	19,66	0,931
	B1	19,03	19,97	0,795
	C1	19,61	19,39	0,954
	D1	18,79	20,21	0,708
2	A2	19,89	19,11	0,840
	B2	18,89	20,11	0,751
	C2	19,03	19,97	0,795
	D2	20,00	19,00	0,795
	E2	18,97	20,03	0,773

Table 3-2 Validation results for the audit checklist

3.7.2 Questionnaire

The questionnaire (Appendix D1) was used in levels 2, 4, 6, and 8 (table 3.1). It was designed to assess the attitude of the personnel involved in the food processing towards HACCP system, and provides valuable information regarding successful implementation of the system. The attitude of personnel could be positive or negative depending on the level of difficulty they faced in implementing HACCP and the barriers they encountered. This attitude depends on the level that the system affects their everyday work. Negative attitude tends to be one of the barriers in implementing the system. When personnel have a negative attitude towards HACCP application of the system becomes difficult. In particular, this attitude acts as a barrier to the effort made for a change in food safety culture. Thus, a change in attitude could indicate the satisfaction of the enterprises with implementing HACCP and whether HACCP could be used effectively in the long run. In order to measure this change in attitude the results from each questionnaire were compared at the different levels (chapter 4, section 4.6).

The same questionnaire was applied to all 50 premises at the four different levels (table 3.1). The first evaluation of the questionnaire was performed after the implementation of the PRPs in level 2, the second evaluation after the implementation of the seven principles of HACCP system in level 4, the third evaluation after the implementation of CYS244 in level 6, and the fourth evaluation after the implementation of ISO22000 in level 8.

3.7.2.1 Selection of Method

One of the main objectives of the research was to assess the attitude of the personnel involved in the implementation of HACCP. A self-administered questionnaire was selected as a data collection method used for the assessment.

The majority of the enterprises in Cyprus are family owned and the owner/manager is also one of the food handlers. For this reason only one questionnaire was designed and was completed by the manager/owner of the enterprise. A Likert-type scale was developed reflecting clearly positive or negative attitudes towards HACCP system. This type of scale was chosen due to the simplicity of its construction and the straight forward interpretation of the results. After validity and reliability procedures the final questionnaire comprised 14 questions. The first 13 questions are listed on a 6-point Likert scale with a score 1 representing the minimum score of the answer on the question and 6 indicating the higher score of the answer on the question. For some of the questions reverse-phrasing was considered before any reliability test, that is the questions were phrased the opposite way around to all other items. Reverse phrasing includes questions 3, 4, 5 and 6, in which case the ranking was reversed before analysing them. This can reduce response bias (Field, 2005). In this case 1 is the highest mark and 6 the lowest. The final question is a YES/NO question on whether the system should be stopped or not. This is analyzed separately. The questionnaire is available in Appendix D1.

3.7.2.2 Validation of Questionnaire

No published questionnaire assessing attitude towards HACCP system was available at the time of the study (2005). In order to ascertain the content of the questionnaire was appropriate and relevant to the study purpose the researcher undertook a thorough literature review and sought expert opinion. Five chosen experts, two food safety consultants and three statisticians, in the areas of questionnaire design, statistics and food safety were asked to review a first draft of the questionnaire including a preliminary pool of 25 questions generated by the researcher based on what the questionnaire was measuring. Upon the opinions provided by the experts six questions were eliminated leaving 19 questions. Of the six eliminated questions one was eliminated due to repetition, one due to low concurrence and four due to irrelevance.

The remaining 19 questions were examined to assess the reliability of the questionnaire. To test the reliability and internal consistency of the questionnaire as a whole, Cronbach's alpha (α) coefficient was calculated using the SPSS package. The Cronbach's α (or the internal consistency reliability) is a statistic correlation coefficient that is used to measure reliability. This measure determines how well a set of items (or variables) correlate with each other (Field, 2005). Results showed an alpha coefficient of α=0.28 which is low (table 3.3). To improve the internal consistency of the questionnaires 5 questions were dropped based on the items´ contribution to the test if removed and on the opinion of the experts, leaving 14 questions for the final questionnaire. The five questions dropped recorded general comments on HACCP system rather than on the managers'/owners perception of food safety management and HACCP system. The reduction led to an improvement of Cronbach's α which shows the value of α=0.5 (table 3.3). This value is not that high (>0.70) but this, as explained by the statisticians, is rather due to the heterogeneity of the items asked. Table 3.4 shows that no further drop of questions would alter Cronbach's α significantly.

The final questionnaire as shown in appendix D1 consists of the 14 questions together with 5 additional questions regarding demographic information of the enterprises. The final questionnaire was pilot tested. The questionnaire was given to 15 managers from the study group and 5 experts to review seeking individual feedback. No negative feedback was given.

Reliability Statistics
(Before Reduction)

Cronbach's Alpha	N of Items
.280	19

Reliability Statistics
(After Reduction)

Cronbach's Alpha	N of Items
.500	14

Table 3-3 Cronbach's α for validation of the questionnaire

Question No	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1	39.58	18.902	.032	.514
2	39.46	17.845	.194	.479
3	41.14	17.960	.153	.488
4	41.50	17.194	.275	.459
5	39.80	16.980	.328	.448
6	41.22	17.726	.149	.490
7	40.08	17.789	.168	.484
8	40.22	17.277	.149	.492
9	41.32	16.916	.329	.447
10	40.92	17.504	.190	.479
11	39.08	17.463	.238	.468
12	40.42	17.147	.176	.484
13	39.28	18.451	.065	.510
14	43.56	19.313	.156	.493

Table 3-4 Validation results for the questionnaire

3.7.3 Environmental, Food and Water Samples

Laboratory analyses are considered to be one of the most objective ways of hygiene practices and food safety measurements. In order to measure food safety and hygiene practices, environmental, food, and water analyses were conducted by accredited laboratories in Cyprus. All these laboratories were accredited according to the international standard ISO17025 (ISO, 2005b) and the accredited body was the accreditation department of the Ministry of Commerce, Industry and Tourism in Cyprus. The four laboratories that participated in the research were: FoodTec Laboratory, P.T.A. FoodLab and Nutritional Services Ltd, FoodLab Ltd, and Envitech Ltd (Laboratory of Environmental Technology-Research Institute). All samples were collected by qualified scientists from the accredited laboratories who visited the food premises at prescribed intervals during the different levels of the project (levels 1, 2, 4, 6 and 8; table3.1). The microbial examination performed by the accredited laboratories indicates the number of microbes existing in the samples. By comparing these results of the microbial examinations with the standard acceptable limits defined by the general chemical state laboratory in Cyprus, the level of compliance can be concluded. The microbiological examination and chemical analysis was all carried out according to standard methods. These are indicated in the relevant section.

3.7.3.1 Environmental Samples

As stated in the literature, food handlers' poor hand washing practices, and poor personal hygiene in general, have been implicated in food outbreaks since they can cause spread of contamination within a food processing environment (Giampaoli *et.al.*, 2002; Montville *et al.*, 2001). Bloomfield (2003) and Green *et al.* (2006), argue that hands are the means of transferring bacteria from contaminated objects on food.

Studies reported that appropriate hand washing practices can lower Total Viable Counts (TVC) and coliform counts (Kennedy *et al.*, 2005).

Surface testing of food production surfaces and equipment is a very common test in the industry since they are simple and cheap to apply and can evaluate areas with high potential of contamination (Holah *et al.,* 1998; Swanson and Anderson, 2000). According to Kusumaningrum *et al.* (2003), potential microbial cross contamination resulting from contact, based on the detachment of surface-bound microorganisms, can be measured by microbial surface swab tests. Both hand and surface testing can take the form of swabbing. Swabbing is the most widely used method for the microbiological examination of surfaces in food and dairy industries and restaurants (Jay *et al.*, 2005).

Work Surfaces

In order to examine the cleaning and disinfection, samples from work surfaces in the premises were taken and analyzed by qualified scientists from the accredited laboratories. Surface samples were taken at the end of levels 1, 2, 4, 6, and 8 of the implementation of the system (table 3.1). The surface samples form each level were taken by scientists and they tried to take the samples from the same place form each of the enterprises. A sample from a clean stain-less steel surface was chosen in order to measure the level of cleanness and sanitation on food contact surfaces. The surface sample was collected from the production area which was the high-risk area with the highest possibility of cross contamination according to the following procedure:

- the swab was hydrated with letheen broth
- the sample area (64 cm^2) was swabbed, using a template, by quickly moving the swab width-wise back and forth along the surface
- the swab was placed back in the container with the letheen broth, sealed and transported to the laboratory.

The entire content of the quick swab was taken to the laboratories for the microbiological analyses. During the analyses the contents of the quick swab were poured onto 3M petrifilm. The petrifilm were incubated at 30˚ for 72 hours. A sample of the surface swab test analyses results are presented in Appendix B1.

Hand Swabs

To examine the personal hygiene of staff, scientists collected microbial hand swab samples from one worker from each enterprise. The worker chosen was the person in charge for food preparation. An employee's hand can give a good indication of their personal hygiene as well as the resulting cross contamination onto ready to eat food in the premises that were in a critical position (production area). An area of 25 cm^2 was swabbed with the use of a steel template to outline the swabbing area of the hand. The hand swabbing technique used was the same as described above for the surface swabbing.

For both hands and surface samples, the TVC were examined. TVC measures the total number of culturable bacteria (per volume or area) in a given sample. The analyses results are presented in the next chapter and the conclusions are analyzed in the Discussion chapter. A sample of the hand swab test analysis results are presented in Appendix B2.

3.7.3.2 Food Samples

The food samples were collected from the products of each enterprise and from the incoming goods. Food samples were taken at the end of levels 1, 2, 4, 6, and 8 (table 3.1). Each food evaluation included five high risk food samples according to the enterprise's products. Examples of high risk food included food cooked with different kinds of sauces and creams, products with mince meat, salads etc. The more sensitive ingredients included in a food, the more high risk the food is. A plan for the food evaluations for each enterprise was prepared by the researcher in collaboration with scientists from the laboratories conducting the analyses. The food evaluation plan was based on the high risk food products as well as the CCPs that were under control. The food samples collected were examined for different kinds of bacteria depending on the food category. The relevant bacteria that had to be tested for each food category are provided in the guide of "Microbiological Criteria for Food" of the general chemical state laboratory in Cyprus (Appendix B5). The acceptable limits were also included in the guide. A sample of the food analysis results are presented in Appendix B3. The meat samples that were analyzed by the laboratories that performed the analyses and the method used for each parameter (pathogen) is shown in table 3.5. The pathogens chosen to be analyzed for each food sample (tables 3.5, 3.6) were based on the Microbiological Criteria for Food" of the general chemical state laboratory in Cyprus (General chemical state laboratory, 2001) and the Commission regulation (EC) No 1441/2007 on microbiological criteria for foodstuffs. For pastry, restaurants, and fast food samples, the laboratories performed the analyses shown in Table 3.6.

Parameter	Standard
Coliforms	ISO 4832:1991
E-coli	ISO 16649-2:2001
Clostridium perfringens, Staphylococcus aureus (+) Salmonella spp	FDA

Table 3-5 Parameters for meat analysis with accredited method

Parameter	Standard
E-coli Staphylococcus aureus (+) salmonella spp Clostridium perfringens Bacillus.cereus	FDA
Aflatoxins Total Number of Bacteria	ISO 4833:1991
Enterococcus spp	ΕΛΟΤ:947.2:1996
Faecal coliform	APHA 9221 E:1992

Table 3-6 Parameters for pastry and fast food analysis with accredited method

3.7.3.3 Water Samples

Water samples were taken by microbiologists from the laboratories that have been involved in the research, from the taps of the production area, in order to analyze the water used by the premises. Water samples were taken from the same source throughout the five analyses that conducted at the end of levels 1, 2, 4, 6, and 8 (table 3.1). A sample of the water analysis results are presented in Appendix B4.

Parameter	Applied Standard / Techniques
Total Number of Bacteria	CYS EN 6222:1999
Coliforms	APHA 9222 B:1992
F. coliform	APHA 9221 E:1992
Enterococcus spp.	ΕΛΟΤ:947.2:1996

Table 3-7 Parameters for chemical water analysis with accredited method

Chemical analyses of the water samples were performed, examining the parameters shown in table 3.7 (APHA, 1992). Water samples were taken in order to check the quality of the water as the enterprises were using it in the production. Microbiological analyses of the water samples were performed in order to examine the parameters shown in table 3.8.

Parameter	Applied Standard / Techniques
pH	ΕΛΟΤ:658:1983
$CaCO_3$	APHA 2320 B:1998
Cl	APHA 4500-Cl(B):1992
SO_4	APHA 4500- SO_4 (E):1992
NO_3	APHA 4500- NO_3 (E):1998
NO_2-N	APHA 4500- NO_2 (B):1998
Na	APHA 3500- Na (D):1992
K	APHA 3500- K (D):1992
Ca	APHA 3500- Ca (D):1992
Mg	APHA 3500- Ca(D):1992

Table 3-8 Parameters for microbiological water analysis with accredited method

3.7.4 Test

A test was applied in all 50 enterprises to assess the knowledge and the understanding of the personnel on the hygiene levels, the HACCP system, and the food safety. All the employees from each enterprise involved in the implementation of the system which participated in the training sessions undertook the test. The total number of personnel that undertook the test was 438.

Three different tests Test1, Test2 and Test3 (Appendices C1-C3) were designed and were performed over the three levels 1, 2, and 6 respectively (table 3.1). The three tests were developed using revision questions from Griffiths (2001). For Test3 additional questions were added from CYS244 standard. The tests were reviewed by expert colleagues of the researcher and EHOs. The tests were applied to all personnel involved in the system. Test1 was administered to the enterprises before any training to assess the understanding and knowledge of food safety and hygiene of the personnel. Test2 was administered after the first training on PRPs to the personnel involved in the training in order to check for any improvement in their knowledge after the training. Test3 was administered in level 6 after the training on the CYS244 standard in order to check any improvement in their knowledge on food safety. Each test consisted of two parts (Part A and B). Part A remained the same in all three tests. Part B was different over the three tests based on the training that had been performed during levels 2 and 6 (table 3.1). Part A consisted of five questions. Each question was assigned a mark ranging from 0 to 2, and the total score for part A was 10 marks. This part included basic food hygiene questions regarding the understanding of the main purposes of the HACCP system, food safety issues, and the application of the system. These questions remained the same over the 3 tests in order to assess the knowledge of the personnel and whether or not there was an improvement through the implementation of the system and the training sessions.

Part B consisted of multiple choice questions and was different over the three tests. Part B of Test1 consists of 40 questions each presented with a picture. The examinee had to complete next to each picture the symbol √ for a correct picture and an X for an incorrect picture. Each question was assigned 0,25 marks. The total score of Part B was 10 marks. This part of Test1 was designed to be very simple to examine the basic knowledge of the personnel involved. The personnel that undertook the test were supposed to know the basic hygiene practices. The researcher tested their knowledge before any intervention. Appendix C1 shows the questions of Test1.

Part B of Test2 consisted of 10 multiple choice questions, 1 point each. These questions were basic questions on the PRPs. Test2 was performed at the end of level 2 (table 3.1) after the training on the PRPs. Appendix C2 shows the questions of Test2. The researcher tested the personnel's knowledge on PRPs after the training. The test included questions on personal hygiene, cleaning and sanitation, pest control, temperature control, and cross contamination. It was important for the personnel to understand PRPs as these were the foundation on which the HACCP plan was built in each enterprise.

Part B of the Test3 consisted of 20 multiple choice questions. Each question was assigned 0,5 marks. These questions tested the HACCP principles, hazard identification and HACCP terminology according to the food safety standard CYS244. Test3 was applied in order to determine the personnel’s knowledge after the conduction of the training on the food safety standard CYS244 that was performed in level 6 (table 3.1). Personnel involved in the training had to know the HACCP principles, HACCP identification and terminology, procedures on maintenance of the system, and management. Appendix C3 shows the questions of Test3.

3.7.5 Cost

During this study the cost of the implementation of the system and the cost of the infrastructure changes were collected per premise. Data on the implementation costs that included consultation and training was collected from the consultancy offices of the researcher’s background in Cyprus. The cost for the implementation of the system was calculated on the time spent on the development of the system. This was charged using a cost of €65/hour. The implementation cost values were estimates based on the available time schedule spent in each enterprise. Data on the infrastructure costs (real numbers) was collected from the businesses’ accountants after permission. Data included all the building and equipment changes that the premises had to do due to the PRPs requirements. Costing was calculated at the end of the implementation of system.

4 RESULTS

4.1 Introduction

This chapter presents the statistical analysis performed on the various data of the study and gives the results. An analytic interpretation of the results is presented in the Discussion chapter. In order to perform the analysis the statistical package SPSS 16 for Windows was used.

4.2 Outline of the Analysis

As mentioned in chapter 3, 50 food SMEs from Cyprus were selected for participating in the study. Having outlined the framework for data collection, statistical analysis was conducted and is presented below. The data analysis included all data collected for the purpose of this study including, audits, questionnaires, tests, environmental samples (surface and hand swab tests), food and water analyses, and costs.

The analysis starts by analyzing the normality of the data. In this way the data can be summarized compactly and the proper statistical tests can be carried out in order to gain valuable information (Chambers *et al.*, 1983). For this purpose the Kolmogorov-Smirnov and Shapiro-Wilks (Shapiro and Wilk, 1965; Royston, 1992; Conover, 1999) tests for normality were performed. As most of the data are not normally distributed, that is they are not clustering around the mean, non-parametric tests were used for the analysis. In particular, for data comparison and to test for significant differences between related data of the analysis, Friedman's test, Wilcoxon Signed-Rank test, Kruskal-Wallis test, and Mann-Whitney test were used (Field, 2005; Friedman, 1937; Gorder and Foreman, 2009) where appropriate. For example, by testing the results of the audit checklist one can conclude whether the companies get better or worse in the application of the system. Differences were considered to be significant or not-significant using the appropriate Bonferroni correction for each case (Field, 2005).

In what follows a comprehensive analysis is presented of all the results for each evaluation conducted in the different levels of the implementation of the system (table 3.1). Results are given in the following sequence:

- The results are first analyzed using the audit checklist (Appendix A1);
- The employees' tests (Appendix C) are then analysed;
- An analysis of the cost for applying the system is given;
- Analysis of the attitudes of the managers and owners towards the different levels of the implementation of the system (results of questionnaire / Appendix D2).
- Environmental and food laboratory analyses of surfaces, personnel hands, water, and food (Appendix B).

4.3 Analysis of Audit Results

The auditing process is based on the audit checklist given in Appendix A1. This contains five sections:

- Part A: "Building and Facilities", covering 33 items,
- Part B: "Cleaning and Disinfection", covering 20 items,
- Part C: "Production and Process Control", covering 18 items,
- Part D: "Performed Evaluations", covering 5 items, and
- Part E: "HACCP System Documentation", covering 99 items.

One audit was performed at the end of levels 1, 2, 4, 6 and 8 for each of the enterprises. Each level represents the different stages of the implementation of the system as shown in table 3.1 in the Research Methodology chapter. Table 4.1 summarizes the mean scores of the sample group of the 50 businesses for Parts A, B, C, D, and E to the corresponding levels.

Level	Audit	Part A Mean score (*n*=50)	Part B Mean score (*n*=50)	Part C Mean score (*n*=50)	Part D Mean score (*n*=50)	Part E Mean score (*n*=50)
1	1	10.82	12.04	11.64	1.94	-
2	2	25.00	17.84	13.06	2.30	-
4	3	26.62	19.10	13.96	4.64	84.66
6	4	27.46	18.20	15.36	4.92	88.14
8	5	27.46	16.46	12.90	4.92	62.04

Table 4-1 Summary mean scores for parts A-E of the analysis of the audit results

Results for each part are analyzed and presented separately below.

4.3.1 Part A: Building and Facilities Audit

The audit score for each enterprise for Part A: “Building and Facilities” was performed through five audits (Audit1 - Audit5) during levels 1, 2, 4, 6 and 8, to enable the follow up of any progress in this field (table 3.1). The questionnaire used comprises 27 questions covering 33 items as shown in Appendix A1. One unit was assigned for each YES reflecting the items for which the establishment satisfied the requirements. The final score for each establishment in an audit thus shows the number of Yeses that reflect the requirements satisfied at that audit. The maximum score (i.e. all yeses) would be 33.

Before adopting the most appropriate test, an exploratory analysis was performed together with a test for the normality of the data. The statistical results for Part A: “Building and Facilities” of the audit checklist are given in Appendix A3. In particular, the box plots and histograms of the data are presented in figures 4.1 and 4.2.

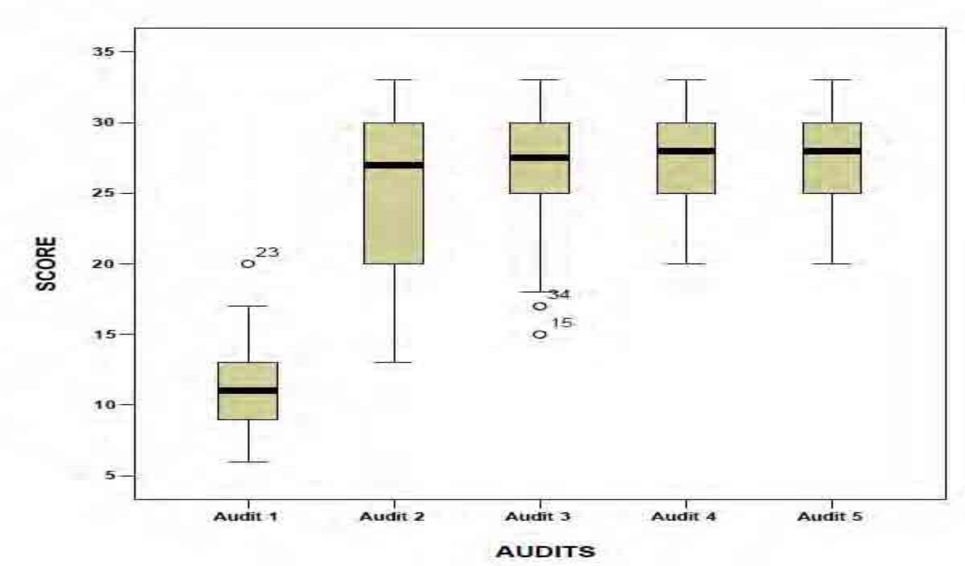

Figure 4-1 Box plots for Part A: “Building and Facilities” of the audit checklist

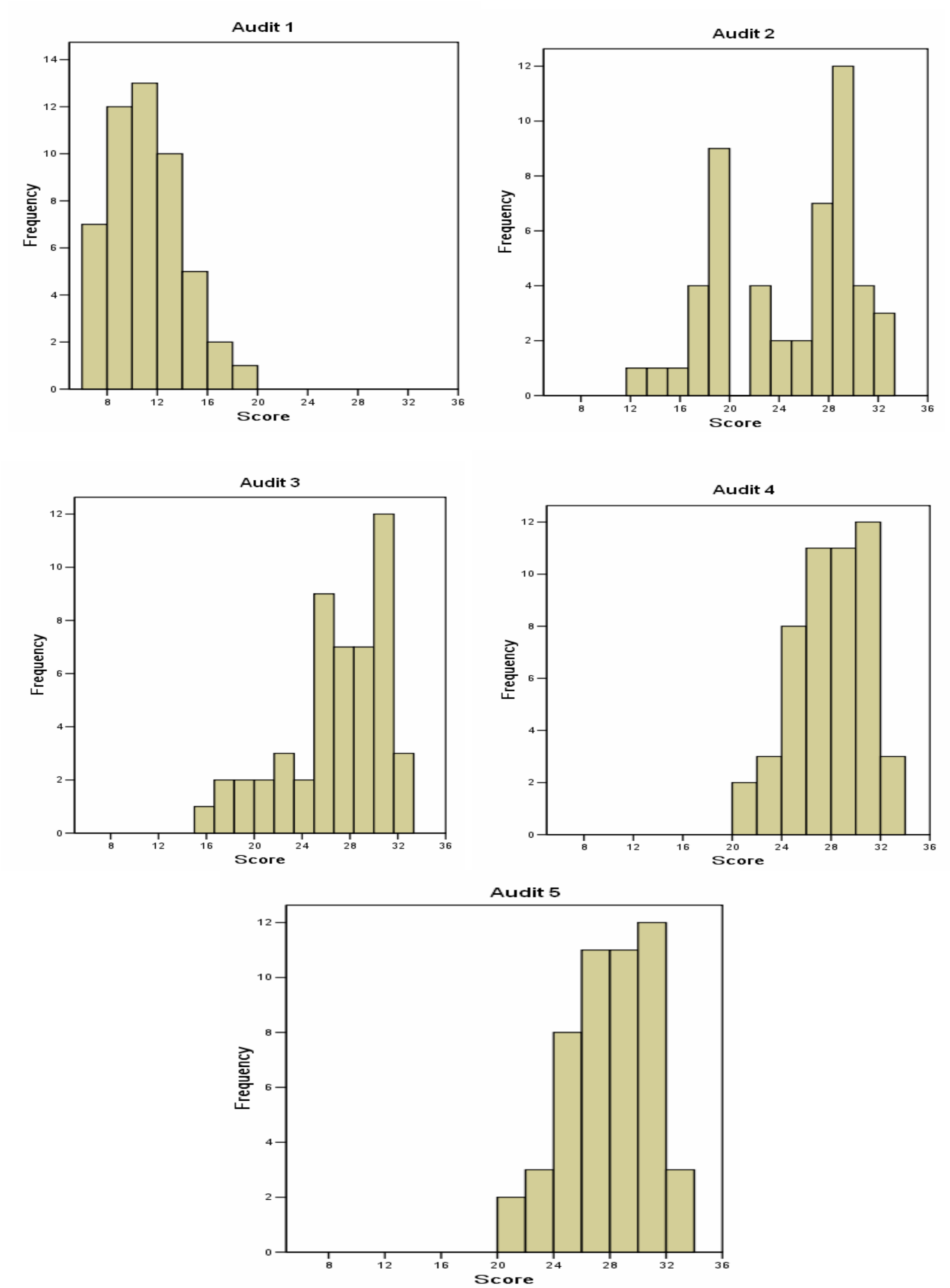

Figure 4-2 Histograms for Part A: “Building and Facilities” of the audits checklist

The box plots (figure 4.1) give a graphical display of the distribution of the scores in Audits 1-5 and provide an indication of the data's symmetry and skewness. The points outside the ends of the vertical lines shown with circles are outliers, that is, scores that diverge greatly from the overall pattern. The horizontal line inside the box represents the median of the scores. When the median is not in the centre of the box the distribution is skewed and thus not normally distributed. From both the box plots and histograms the data for some of the audits results are shown to be not normally distributed. Tests for normality were also performed and particular Kolmogorov-Smirnov and Shapiro-Wilks goodness-of-fits tests. The results are shown in Appendix A3. These results also indicate non-normality for most of the data. Based on this and the fact that the data are ordinal not metric a non-parametric test was used for testing the significant differences between the audits.

Since the same enterprises were evaluated at each level, the data are considered to be not independent so a non-parametric test for five related samples was used. In particular Friedman's test was used. The results are shown in tables 4.2 and 4.3. Table 4.2 shows a significant increase in the mean score from the first to the fourth audit, and no increase from the fourth to the fifth audit. The increase results from the intervention made in the premises of the enterprises and in the application of PRPs. A p-value less than 0.05 is said to be statistically significant. From table 4.3 the p-value of the test is p=0.000 which is highly significant i.e. there are significant differences in the mean scores between the part A (building and facilities) of the five audits.

Part A: "Building and Facilities"	N	Mean	Std. Deviation	Minimum	Maximum
Infrastructure Score Audit1	50	10.82	3.028	6	20
Infrastructure Score Audit 2	50	25.00	5.429	13	33
Infrastructure Score Audit 3	50	26.62	4.285	15	33
Infrastructure Score Audit 4	50	27.46	3.059	20	33
Infrastructure Score Audit 5	50	27.46	3.059	20	33

Table 4-2 Descriptive statistics for Part A: "Building and Facilities" of the audit checklist at the different levels

Test Statistics[a]

N	50.000
Chi-Square	169.159
Df	4.000
Asymp. Sig.	.000

a. Friedman Test

Table 4-3 Friedman test statistics for Part A: "Building and Facilities" of the audit checklist at the different levels

A paired-data 2 sample Wilcoxon Signed Rank Test is used to test for significant differences between consecutive audit scores. That is, the test compares the scores at audits 1:2, 2:3, 3:4 and 4:5. The critical level for the Wilcoxon signed-rank tests, using the appropriate Bonferroni correction (Field, 2005), is 0.05/4=0.0125. Table 4.4 summarises the results from the tests. Actual calculations of the pair-wise application of the Wilcoxon test are given in Appendix A3.

	Compare Audit2:Audit1	Compare Audit3:Audit2	Compare Audit4:Audit3	Compare Audit5:Audit4
Z^a	-6.159	-3.463	-2.060	.000
Asymp. Sig	.000	.001	.039	1.000

Table 4-4 Summary significant differences between consecutive audits in Part A: "Building and Facilities"

The results show

- a highly significant difference between audits 1 and 2;
- a highly (but slightly smaller than before) significant difference between audits 2 and 3;
- no significant difference between audits 3 and 4;
- no significant difference between audits 4 and 5.

This decrease in the significant difference through the five audits was due to the fact that most of the enterprises completed all necessary infrastructure changes required early in the study with only minor changes in the last stages.

4.3.2 Part B: Cleaning and Disinfection

The audit score for Part B: "Cleaning and Disinfection" of the audit checklist comprises 20 items shown in Appendix A1, and one unit was given for each YES reflecting the item that satisfied the requirements. The maximum score that could be achieved is 20.

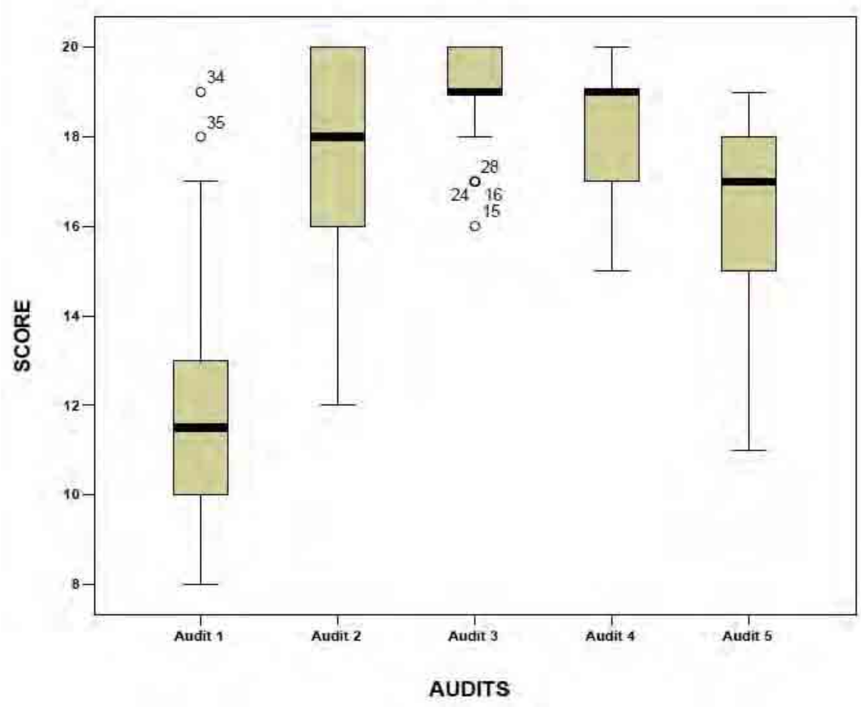

Figure 4-3 Box plots for Part B: "Cleaning and Disinfection" of the audit checklist

To begin with, as in Part A, an exploratory analysis and a test for the normality of the data are performed. Figures 4.3 and 4.4 present the results in the form of box plots and histograms showing a non-normality of the data. Kolmogorov-Smirnov and Shapiro-Wilks tests for normality are also performed. The results are given in Appendix A3 confirm the previous figures for the non-normality of the data. For both tests the significant value is less than 0.01.

In what follows, since the data were not independent and are ordinal, Friedman's non-parametric test for the difference between the audits was used. The results presented in tables 4.5 and 4.6 show, as before, and increase in the mean scores from the first to the third audit, and a decrease in audits 4 and 5. The differences are significant.

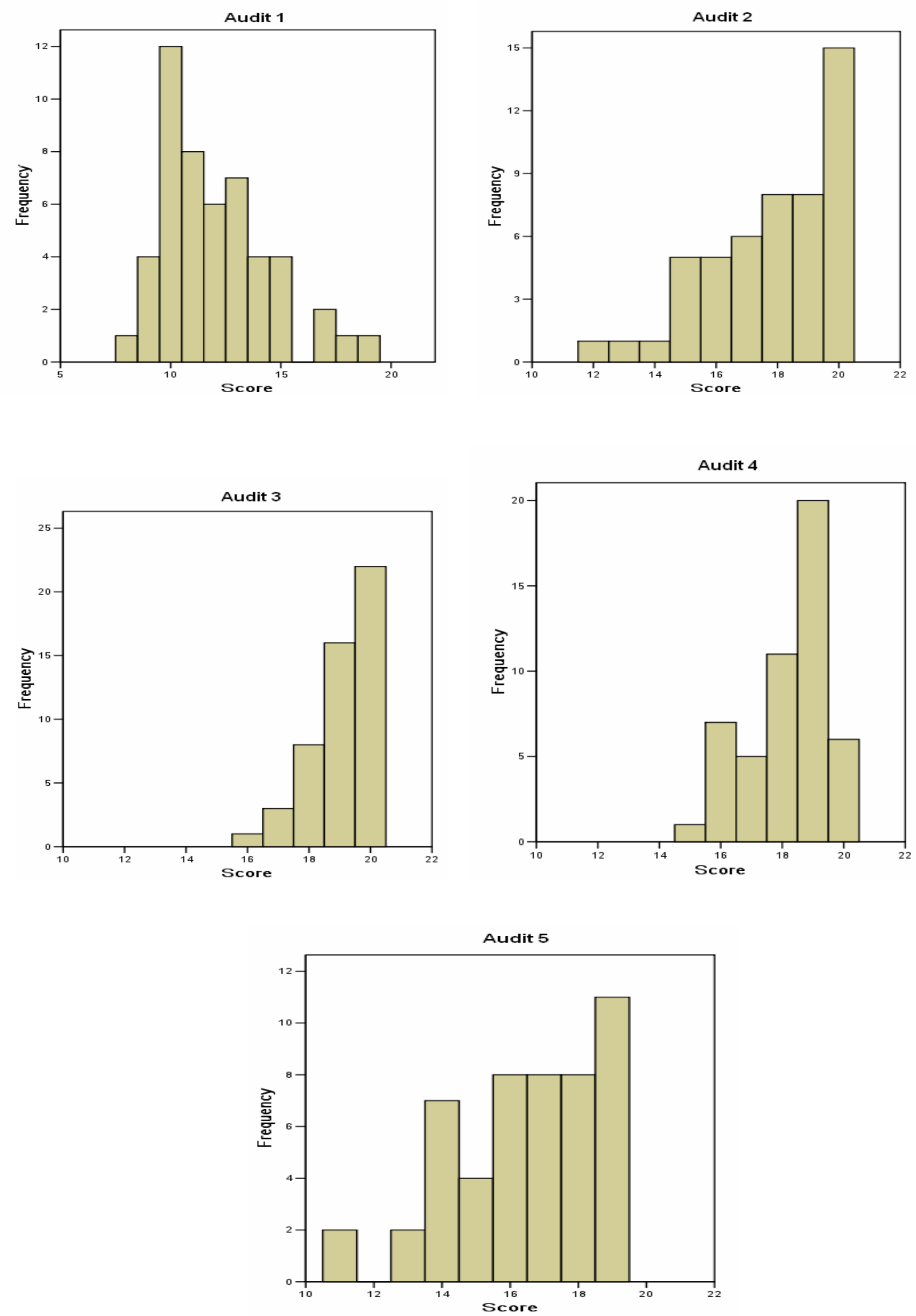

Figure 4-4 Histograms for Part B: “Cleaning and Disinfection” of the audit checklist

Part B Cleaning and Disinfection	N	Mean	Std. Deviation	Minimum	Maximum
Cleaning Score Audit1	50	12.04	2.482	8	19
Cleaning Score Audit2	50	17.84	2.093	12	20
Cleaning Score Audit3	50	19.10	1.015	16	20
Cleaning Score Audit4	50	18.20	1.309	15	20
Cleaning Score Audit5	50	16.46	2.159	11	19

Table 4-5 Descriptive statistics for Part B: "Cleaning and Disinfection" of the audit checklist at the different levels

Test Statistics[a]

N	50.000
Chi-Square	134.628
Df	4.000
Asymp. Sig.	.000

a. Friedman Test

Table 4-6 Friedman test statistics for Part B: "Cleaning and Disinfection" of the audit checklist at the different levels

To check for significant differences between consecutive audit scores the Wilcoxon Signed Rank test is used together with correcting for the number of tests using the Bonferroni correction. Table 4.7 summarizes the results of the tests. Actual results are given in Appendix A3.

	Compare Audit2:Audit 1	Compare Audit3:Audit 2	Compare Audit4:Audit 3	Compare Audit5:Audit 4	Compare Audit5:Audit 1
Z^a	-5.979	-3.653	-3.336	-4.575	-5.371
Asymp. Sig	.000	.000	.001	.000	.000

Table 4-7 Summary significant differences between consecutive audits in Part B: "Cleaning and Disinfection"

Results reveal

- highly significant difference between consecutive audits despite the small change in the mean value as shown in tables 4.5 and 4.7;
- positive differences between consecutive audits (i.e. get better) from Audit1 to Audit3 and then negative (i.e. get worse) from Audit 3 to Audit 5 (Appendix A3);
- a significant improvement, between Audit 1 and Audit 5, mainly due to the infrastructure changes that took place and thus was much easier for the premises to be cleaned.

4.3.3 Part C: Production and Process Control

The audit score for each enterprise for Part C: "Production and Process Control" took place in the same manner as the previous parts, through five audits in different levels (levels 1, 2, 4, 6 and 8) in order to enable the follow up of the progress in the field. It comprises 14 questions shown in Appendix A1; one of them is divided in four parts,

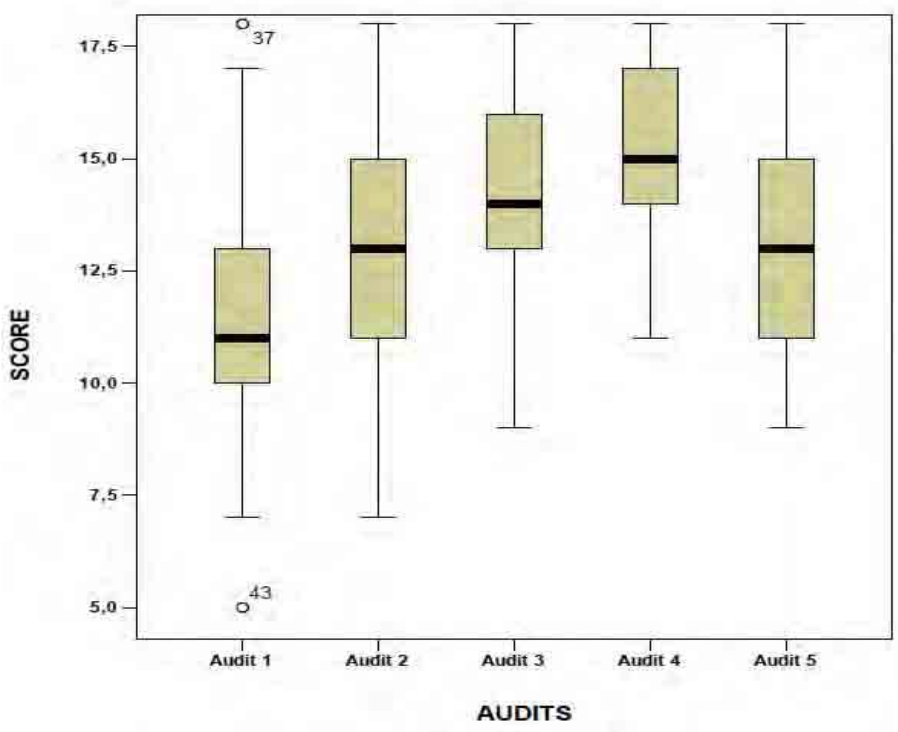

Figure 4-5 Box plots for Part C: “Production and Process Control” of the audit checklist

giving in total 18 items. One unit was given for each YES. The final score is the number of yeses showing the number of requirements satisfied at the audit. The maximum score that could be achieved is 18. The results of the exploratory analysis and the test for the normality of the data are shown in figures 4.5 and 4.6 revealing non-normality of the data.

The results of the Kolmogorov-Smirnov and Shapiro-Wilks tests are given in Appendix A3. The results from both tests reveal that once more normality of most of the distributions is rejected. For this reason and since the data are ordinal the non-parametric Friedman’s test for the differences between the audits is performed giving the results shown in tables 4.8 and 4.9.

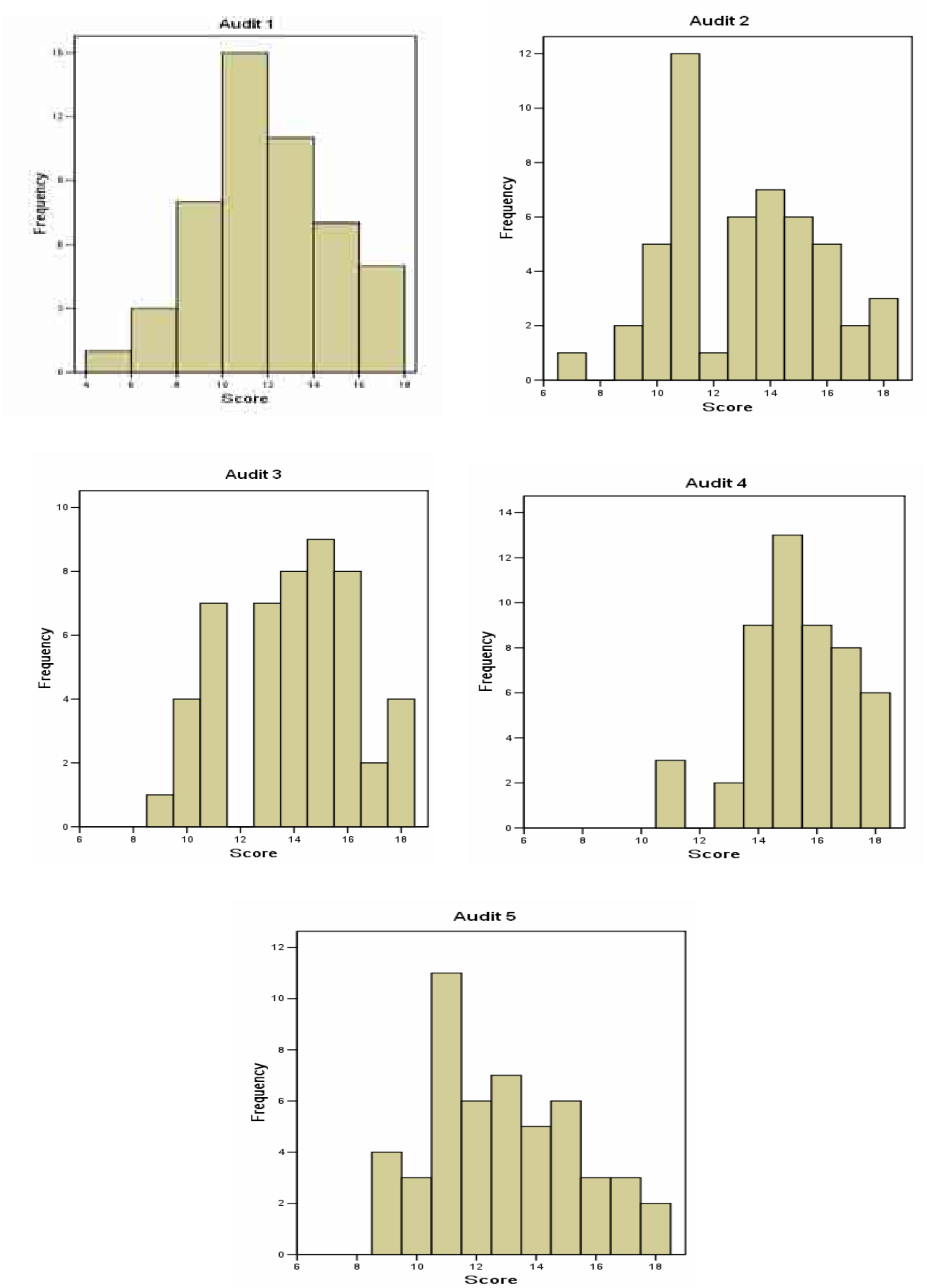

Figure 4-6 Histograms for Part C: "Production and Process Control" of the audit checklist

	N	Mean	Std. Deviation	Minimum	Maximum
Process control score Audit1	50	11.64	2.912	5	18
Process control score Audit2	50	13.06	2.653	7	18
Process control score Audit3	50	13.96	2.399	9	18
Process control score Audit4	50	15.36	1.770	11	18
Process control score Audit5	50	12.90	2.452	9	18

Table 4-8 Descriptive statistics for Part C: "Production and Process Control" of the audit checklist

Test Statistics[a]

N	50.000
Chi-Square	97.107
Df	4.000
Asymp. Sig.	.000

a. Friedman Test

Table 4-9 Friedman test for Part C: "Production and Process Control" of the audit checklist

The mean score values do show a steady increase up to the 4th audit and a sharp drop for the 5th audit (table 4.8). The *p*-value for the test is 0.000 (table 4.9), a highly significant value indicating significant differences in the mean scores between the audits for the "Production and Process Control". The Wilcoxon signed-rank test was used, using the Bonferroni correction. The application of Wilcoxon Signed Rank Test for the test of the differences between consecutive audit scores 1:2, 2:3, 3:4, 4:5 and 1:5 shows highly significant difference between all five pairs (<0.01) (Appendix A3). Table 4.10 gives the summarized significant differences between the consecutive audits.

	Compare Audit2:Audit1	Compare Audit3:Audit2	Compare Audit4:Audit3	Compare Audit5:Audit4	Compare Audit5:Audit1
Z[a]	-5.249	-3.942	-3.846	-5.480	-2.895
Asymp. Sig	.000	.000	.000	.000	.004

Table 4-10 Summary significant differences between consecutive audits in Part C: "Production and Process Control"

The results show

- a highly significant difference between all four pairs of audits despite the small change in the mean value;
- positive differences between consecutive audit pairs 1:2, 2:3 and 3:4 (i.e. get better) which is due to the willingness of the enterprises to apply the system, and then negative (i.e. get worse) for pair 4:5 (Appendix A3) which is due to the fact that most of the enterprises stopped the procedures due to the complexity of the system;
- significant improvement after comparison of Audit1 and Audit 5 mainly due to the infrastructure changes that took place and thus was much easier for the preparation procedures for the production of the food stuff.

4.3.4 Part D: Performed Evaluation

Part D: "Performed Evaluations" had to do with all the laboratory analyses, described in section 3.7.3. The audit score for each enterprise took place through five audits in five different levels (level 1, 2, 4, 6 and 8) in order to enable the follow up of the progress in this field (table 3.1). It comprises 5 items in 3 fields:

1. Water
2. Food
    2.1 Products
    2.2 Incoming goods
3. Environmental
    3.1 Hands
    3.2 Surfaces

One unit was given for each YES reflecting the items for which the establishment satisfied the requirements i.e. carried out the sampling requirement, irrespective of whether the results of the sample showed compliance or not. Compliance with the relevant standards is analyzed in section 4.7, "Laboratory Tests". The maximum score that could be achieved for part D is 5. Figures 4.7 and 4.8 reveal non-normality in the distribution of the data.

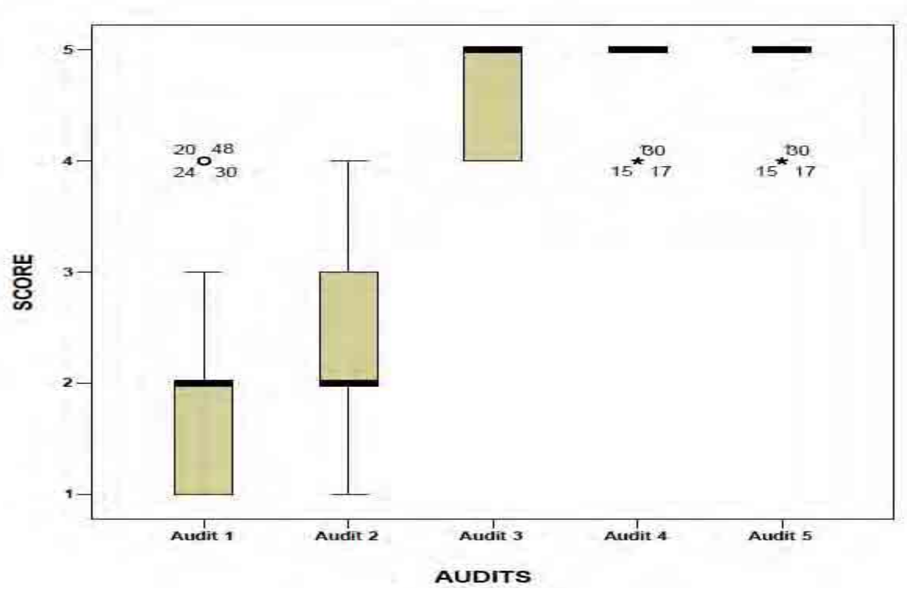

Figure 4-7 Box plots for Part D: "Performed Evaluations" of the audit checklist

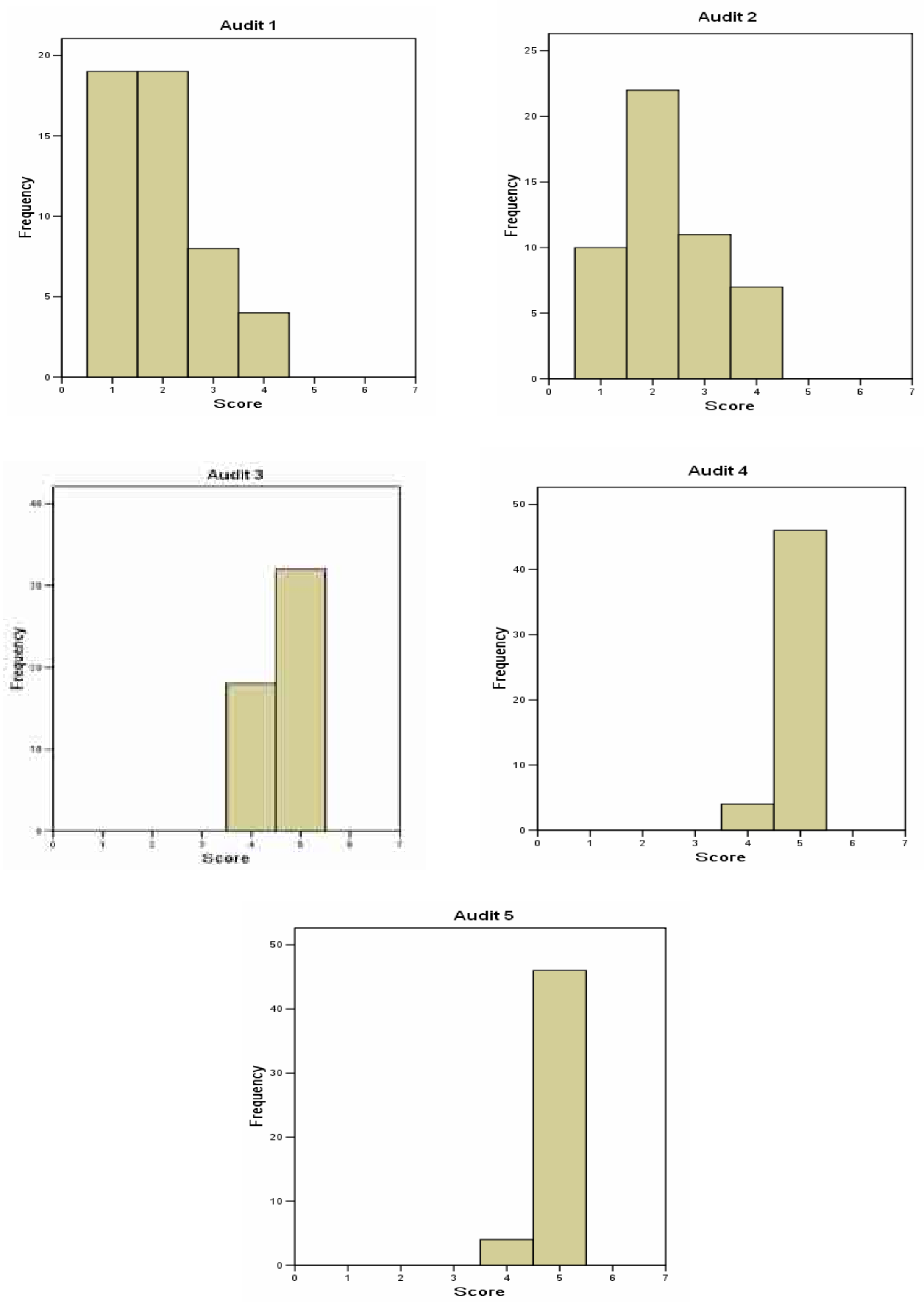

Figure 4-8 Histograms for Part D: “Performed Evaluations” of the audit checklist

	N	Mean	Std. Deviation	Minimum	Maximum
Laboratory analyses score Audit1	50	1.94	.935	1	4
Laboratory analyses score Audit2	50	2.30	.953	1	4
Laboratory analyses score Audit3	50	4.64	.485	4	5
Laboratory analyses score Audit4	50	4.92	.274	4	5
Laboratory analyses score Audit5	50	4.92	.274	4	5

Table 4-11 Descriptive statistics for Part D: "Performed Evaluations" of the audit checklist

Test Statistics[a]

N	50.000
Chi-Square	185.219
df	4.000
Asymp. Sig.	.000

a. Friedman Test

Table 4-12 Friedman test statistics for Part D: "Performed Evaluations" of the audit checklist

The Kolmogorov-Smirnov and Shapiro-Wilks tests are applied and the results are illustrated in Appendix A3. The significant values from the tests reject once more the normality of the distribution.

Tables 4.11 and 4.12 give the results from the Friedman test for the differences between the audits. The *p*-value from the test is 0.000 (table 4.12), a highly significant value indicating significant differences in the mean scores between the audits for the "Performed Evaluations". Looking at the mean scores in table 4.11, a small increase is seen between 1st and 2nd audit, a larger increase from the 2nd to the 3rd, and again a very small increase from audit 3 to 4. No change in the mean value appears from audit 4 to 5.

The results from the application of Wilcoxon test are given in Appendix A3. Table 4.13 gives the summarized significant differences between the consecutive audits.

The results show

- high significant difference (<0.0125) between the first three pairs (table 4.13);
- no significant difference between audits 4 and 5;
- positive difference between consecutive audits for pairs 1:2, 2:3 and 3:4 (i.e. get better) and then negative (i.e. get worse) for pair 4:5 (table 4.1).

	Compare Audit2:Audit1	Compare Audit3:Audit2	Compare Audit4:Audit3	Compare Audit5:Audit4
Z^a	-3.626	-6.140	-3.742	.000
Asymp. Sig	.000	.000	.000	1.000

Table 4-13 Summary significant differences between consecutive audits in Part D: "Performed Evaluations"

4.3.5 Part E: HACCP System Documentation

The audit score for each enterprise for Part E: "HACCP System Documentation" (Appendix A1), concerning the implementation and documentation of the HACCP system, was completed through the last three audits in levels 4, 6 and 8 to enable the follow up of the progress in this field. As opposed to the previous parts, part E could only be completed if an enterprise already had the HACCP system in place. Consequently there was no point for the enterprise to complete Part E in levels 1 and 2. The test comprised 99 items concerning the implementation and documentation of the HACCP system. These items include the food safety policy, HACCP team, product description, flow diagram, the seven principles of the system, non conformity products, traceability, GMP, cleaning, pest control, and training and calibration. One unit was assigned for each YES, giving a maximum possible score in this section of 99.

Table 4.14 gives the analytic results of each enterprise over the three audits 3, 4, and 5. Figures 4.9 and 4.10 show respectively the box plots and the histograms of the audits.

Company	Audit 3	Audit 4	Audit 5	Company	Audit 3	Audit 4	Audit 5
1	90	93	85	**26**	88	88	89
2	89	89	84	**27**	89	89	54
3	88	88	80	**28**	90	90	50
4	78	78	69	**29**	97	97	67
5	79	79	54	**30**	98	98	69
6	80	85	65	**31**	90	90	64
7	85	85	67	**32**	93	93	35
8	87	87	65	**33**	91	91	66
9	85	85	55	**34**	97	97	69
10	89	89	52	**35**	92	92	65
11	92	92	45	**36**	94	94	75
12	79	89	49	**37**	96	96	88
13	97	97	46	**38**	95	95	56
14	80	86	67	**39**	97	97	76
15	85	85	57	**40**	89	89	65
16	82	87	57	**41**	83	89	65
17	83	83	68	**42**	80	85	78
18	80	89	68	**43**	85	90	65
19	73	79	47	**44**	89	95	56
20	69	82	52	**45**	95	95	87
21	68	84	35	**46**	90	90	73
22	69	79	67	**47**	80	87	32
23	60	73	60	**48**	85	92	40
24	70	78	72	**49**	70	83	35
25	80	85	85	**50**	63	79	32
				Total	**4233**	**4407**	**3102**
				%	**86**	**89**	**63**

Table 4-14 Part E audit results for the 50 enterprises over audits 3, 4 and 5

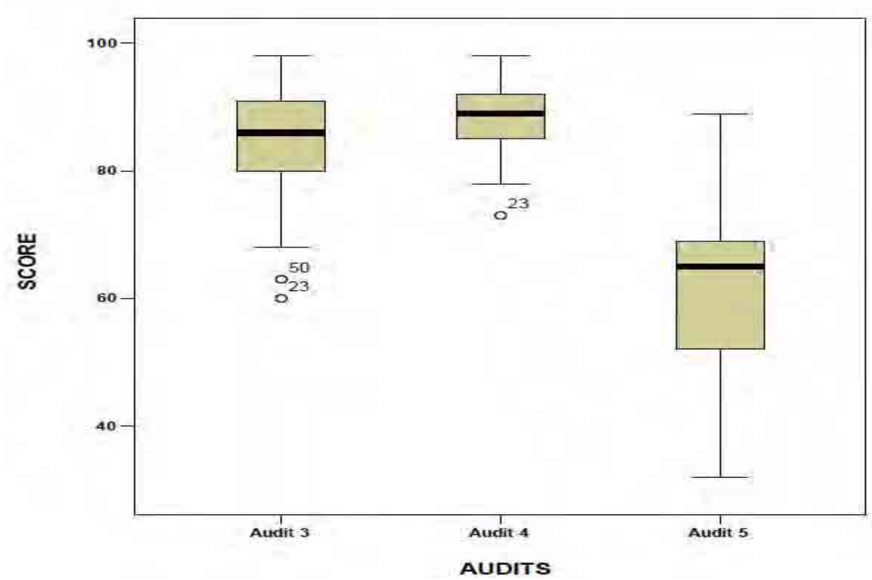

Figure 4-9 Box plots for Part E: "HACCP System Documentation" of the audit checklist

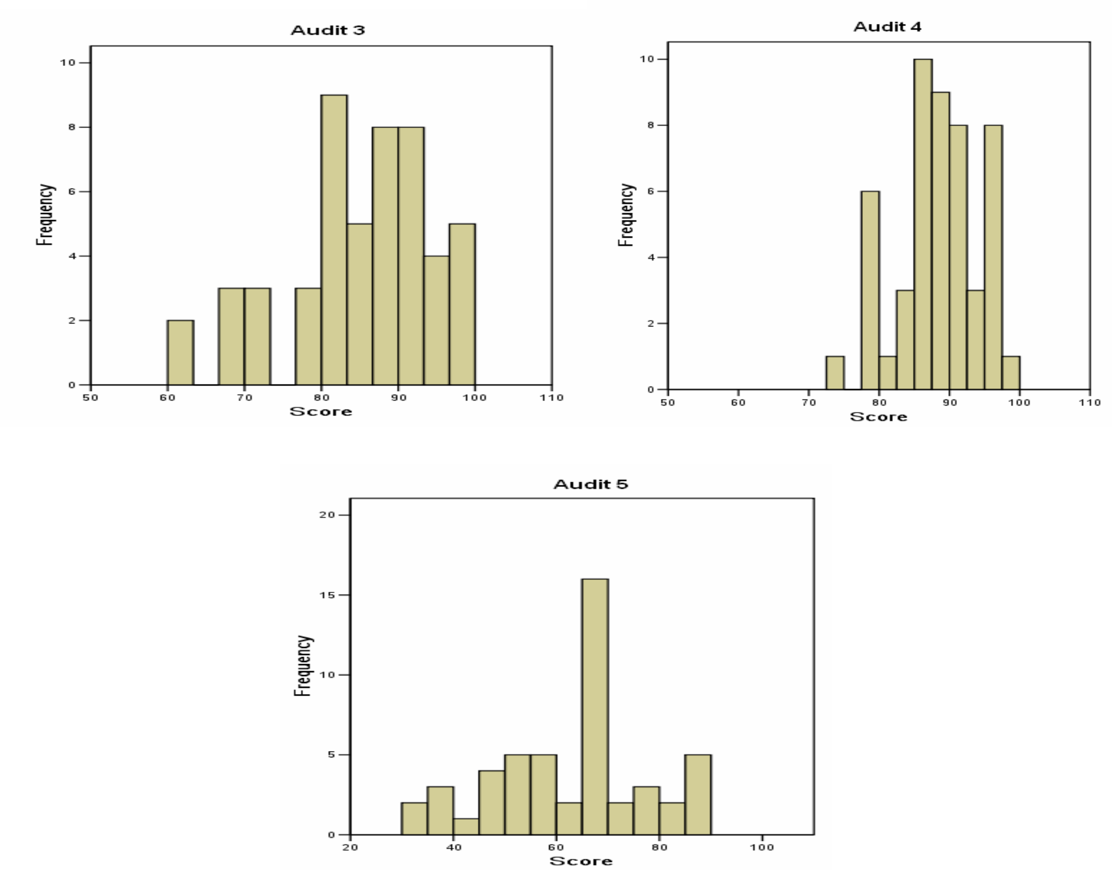

Figure 4-10 Histograms for Part E "HACCP System Documentation" of the audit checklist

HACCP system Documentation	N	Mean	Std. Deviation	Minimum	Maximum
HACCP documentation score Audit 3	50	84.66	9.404	60	98
HACCP documentation score Audit 4	50	88.14	5.911	73	98
HACCP documentation score Audit 5	50	62.04	15.110	32	89

Table 4-15 Descriptive statistics for Part E: "HACCP System Documentation" of the audit checklist

Test Statistics[a]

N	50.000
Chi-Square	78.154
Df	2.000
Asymp. Sig.	.000

a. Friedman Test

Table 4-16 Friedman Test Statistics for Part E: "HACCP System Documentation" of the audit checklist

The results form applying the Kolmogorov-Smirnov and Shapiro-Wilks tests are given in Appendix A3. From the results one can conclude non-normality of the data.

Due to the non-normality, and taking into consideration the size of the sample and the fact that the data are ordinal, Friedman's non-parametric test is applied. The results of the Friedman's test are shown in tables 4.15 and 4.16. The *p*-value from for the test is 0.000 (table 4.16), a highly significant value indicating significant differences in the mean scores between each of the audits for the HACCP System Documentation. The mean scores in table 4.15 reveal a small increase between 3rd and 4th audit, and a large decrease to the 5th audit. The reason for this, as discussed in the next chapter, was the fact that most of the enterprises could not cope with the application of the ISO 22000 (the questions of part B of the audit are applicable for both HACCP system and standards) which is a more complex system compared to PRPs, HACCP, and CYS244. The application of Wilcoxon Test gives the results summarized in table 4.17. Actual results are given in Appendix A3. The results reveal

- highly significant differences from both the 3rd to 4th and 4th to 5th audit with a significant value <0.025;
- negative difference between 4th and 5th audits (i.e. get worse) (Appendix A3s). This, as explained above, had to do with the difficulty for an enterprise to apply a more complex system and is further discussed in the next chapter.

	Compare Audit4:Audit3	Compare Audit5:Audit4
Z^a	-4.026	-6.084
Asymp. Sig	.000	.000

Table 4-17 Summary significant differences between consecutive audits in Part E: "HACCP System Documentation"

4.4 Analysis of Questionnaires

In this section the questionnaire developed and described in chapter 3, section 3.7.2, is analyzed. The questionnaire was given to the managers through four evaluations (E1-E4) conducted in levels 2, 4, 6 and 8 (table 3.1). It must be noted that since most of the enterprises were family owned no distinction could be made between managers and owners. Table 4.18 summarizes the total mean scores achieved by the 50 enterprises over the four evaluations each question of the questionnaire. Actual results are available in Appendix D2. As mentioned in the Methodology chapter, for some of the questions reverse-phrasing was considered before any reliability test, that is, the questions were phrased the opposite way around to all other items. Reverse phrasing includes questions 3, 4, 5 and 6, in which case the ranking was reversed before analysing them. All the questions were explained by the researcher to the personnel and there were relevant in all levels.

Question	E1	E2	E3	E4
1	4.08	3.56	2.08	1.58
2	4.20	3.66	1.88	1.26
3	2.52	3.74	5.00	5.62
4	2.16	3.82	5.36	5.82
5	3.86	4.44	5.28	5.28
6	2.44	3.58	5.08	5.66
7	3.58	3.58	2.18	1.64
8	3.44	3.22	2.50	1.90
9	2.34	2.52	1.96	1.58
10	2.74	2.42	2.02	2.38
11	4.58	4.00	2.66	2.02
12	3.24	4.04	2.70	1.24
13	4.38	4.78	4.42	3.84

Table 4-18 Total mean score of the 50 enterprises for each questions over the four evaluations of the questionnaire

Question	Comparison	Z[a]	Asymp. Sig.[b]	Question	Comparison	Z[a]	Asymp. Sig.[b]
1	E1 : E2	-4.153	0.000	**8**	E1 : E2	-1.520	0.128
	E2 : E3	-6.286	0.000		E2 : E3	-4.826	0.000
	E3 : E4	-5.000	0.000		E3 : E4	-4.524	0.000
2	E1 : E2	-5.014	0.000	**9**	E1 : E2	-2.460	0.014
	E2 : E3	-6.268	0.000		E2 : E3	-4.350	0.000
	E3 : E4	-4.767	0.000		E3 : E4	-4.359	0.000
3	E1 : E2	-5.989	0.000	**10**	E1 : E2	-3.017	0.003
	E2 : E3	-5.570	0.000		E2 : E3	-4.066	0.000
	E3 : E4	-4.031	0.000		E3 : E4	-3.819	0.000
4	E1 : E2	-6.235	0.000	**11**	E1 : E2	-3.737	0.000
	E2 : E3	-6.017	0.000		E2 : E3	-5.497	0.000
	E3 : E4	-4.796	0.000		E3 : E4	-4.101	0.000
5	E1 : E2	-4.761	0.000	**12**	E1 : E2	-4.673	0.000
	E2 : E3	-5.962	0.000		E2 : E3	-5.737	0.000
	E3 : E4	.000	1.000		E3 : E4	-5.636	0.000
6	E1 : E2	-5.487	0.000	**13**	E1 : E2	-3.879	0.000
	E2 : E3	-6.189	0.000		E2 : E3	-3.626	0.000
	E3 : E4	-4.716	0.000		E3 : E4	-4.126	0.000
7	E1 : E2	.000	1.000				
	E2 : E3	-6.299	0.000				
	E3 : E4	-5.014	0.000				

Table 4-19 Summary of the significant differences between consecutive evaluations of the questionnaire

An application of Friedman's non-parametric test to all the same questions over the four evaluations of the questionnaire for each of the 50 enterprises gives a significant value p=0.000 (Appendix D2). This is a highly significant value indicating significant differences in the mean scores between the same questions over the four evaluations of the questionnaire.

In order to test for significant differences between consecutive evaluations of the questionnaire over the same question, the Wilcoxon Signed Rank test was used with a critical value of 0.05/3=0.017 using the Bonferroni correction. Analytical results are presented in Appendix D2. Table 4.19 gives a summary of the significant differences between the 13 questions over the consecutive evaluations of the questionnaire. The last question is analyzed separately below. Actual results are given in Appendix D2. The results from the Wilcoxon Signed Rank test reveal high significant differences for the majority of the questions of the four evaluations of the questionnaire.

As discussed in chapter 3, section 3.8.2, the final question (Question14) of the questionnaire the managers/owners was asking for a YES/NO answer on whether they were considering stopping the system or not. Figure 4.11 gives the percentage results of the answers for the four evaluations of question 14 of the questionnaires.

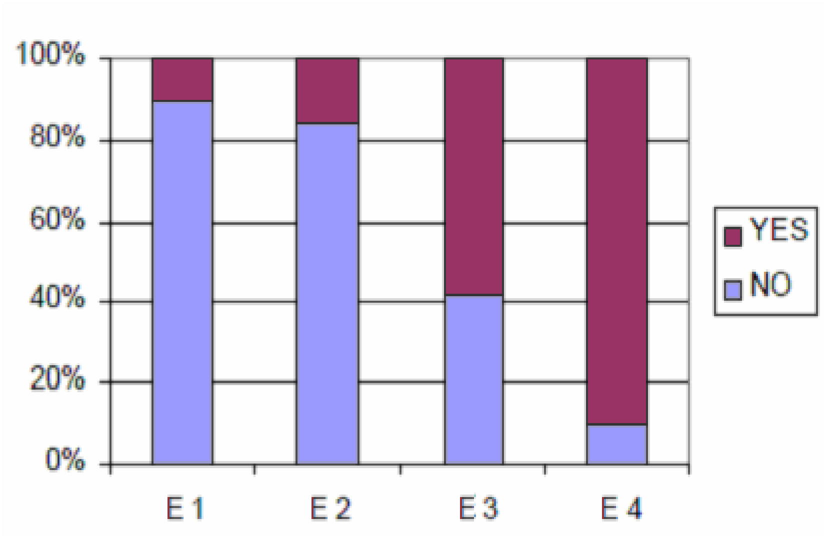

Figure 4-11 Percentage results for the last question of the questionnaire through the four evaluations

The figure reveals an increase in the number of Yeses. In the evaluation E1 there were 5 Yeses, in E2 there were 8, evaluation E3 there were 29, and in evaluation E5 there were 45 yeses. This indicates that more and more owners wanted to terminate the system due both to the complexity of the system and the increase in cost for maintenance of the system.

4.5 Environmental, Food and Water Samples

In the swab tests for both the hands of the employees and the surfaces in the establishments, the results were originally returned in colony-forming-units (cfu)/cm^2. Since measurements take extreme values, microbial counts were analysed using $\log_{10}$ transformation in order to improve the interpretability.

4.5.1 Environmental Samples / Hand Swab Tests

As described in chapter 3, section 3.7.3.1, for the hand swab tests one person from each enterprise was selected giving a total of 50 hand swab samples. Test 1 was performed in level 1, test 2 in level 2, test 3 in level 4, test 4 in level 6, and test 5 in level 8 (table 3.1). The levels of contamination ranged from 1.3 to 4.5 $\log_{10}$cfu/cm^2. For a contamination not detected a score of 0.01 cfu/cm^2 was allocated.

Initially, an exploratory analysis and a test for the normality of the data were performed. The descriptive statistics for the 5 tests are shown in table 4.20.

TEST (n = 50)	MEAN ($log_{10}cfu/cm^2$)
1	3.22±0.48
2	2.94±0.50
3	2.79±0.46
4	2.80±0.53
5	3.03±0.47

Table 4-20 Mean scores for the five hand swab tests

To test the normality of the data box-and-whisker plots are presented in figure 4.12. In the box plot the circles represent outliers and the stars extreme values of the data. Kolmogorov-Smirnov and Shapiro-Wilk normality tests are presented in table 4.21.

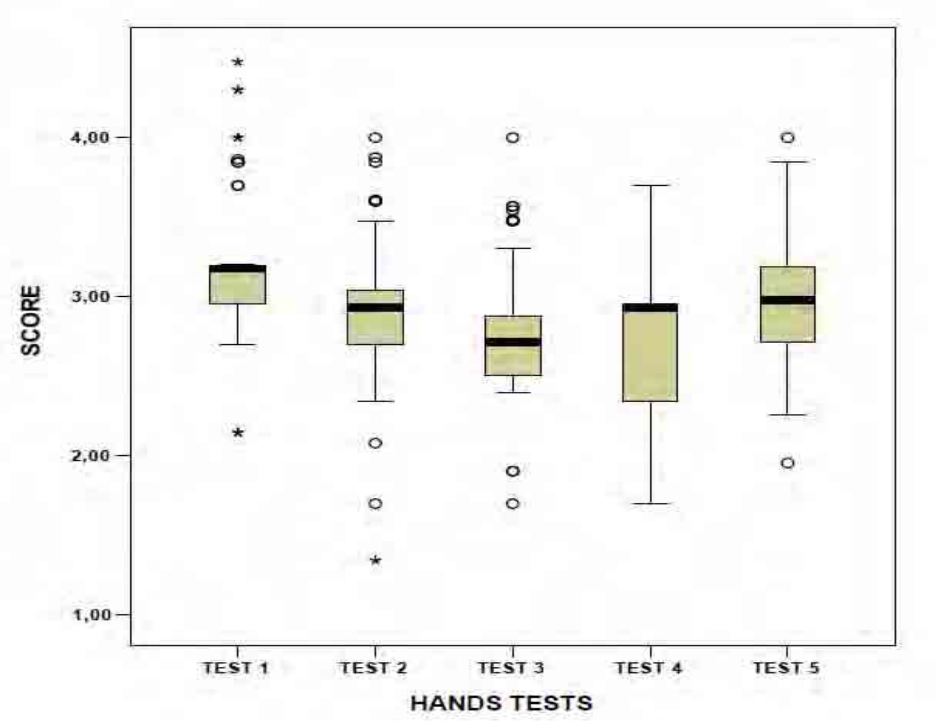

Figure 4-12 Box-and-Whisker plots for the data in the hand swab tests

HANDSTESTS	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
TEST 1	.295	50	.000	.874	50	.000
TEST 2	.203	50	.000	.911	50	.001
TEST 3	.206	50	.000	.922	50	.003
TEST 4	.176	50	.001	.919	50	.002
TEST 5	.130	50	.033	.964	50	.129

a. Lilliefors Significance Correction

Table 4-21 Normality tests for the data in the hand swab tests

As shown in both the box-and-whisker plots and the normality tests performed on the transformed logarithmic data, normality has not been achieved for all sample data therefore non-parametric tests were used for differences between the five sets of measurements.

The table 4.20 shows a drop in the average score from the first test to the second and further in the third test. It follows a small increase in the fourth test and finally an increase in the fifth test. Using the Kruskal-Wallis test a *p*-value of 0.000 (table 4.22) is calculated which is highly significant (<0.05) and indicates that there are significant differences between the hand swab tests in the five rounds.

Test Statistics[a,b]

Chi-Square	34.217
Df	4
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: HANDSTEST

Ranks

HANDSTESTS	N	Mean Rank
TEST 1	50	169.09
TEST 2	50	124.45
TEST 3	50	94.75
TEST 4	50	101.48
TEST 5	50	137.73
Total	250	

Table 4-22 Kruskal Wallis test results for the data in the hand swab tests

	Compare Test2:Test1	Compare Test3:Test2	Compare Test4:Test3	Compare Test5:Test4
Z[a]	-3.511	-2.457	-.470	-2.571
Asymp. Sig	.000	.014	.638	.010

Table 4-23 Mann-Whitney test results for the hand swab tests

Further, the Mann-Whitney non-parametric test for independent samples is used to check for any significant differences between successive test scores. The critical value is 0.05/4=0.0125. The results of the test (table 4.23) show significant differences for tests 1 and 2, and 4 and 5. No significant difference exists between tests 2 and 3, and 3 and 4 (p>0.0125). Actual calculations are given in Appendix B2.

4.5.1.1 Analysis by Activity of Enterprise

In what follows, the four classes of enterprises by activity under study, “Restaurants”, “Fast Food”, “Bakeries” and “Butcheries” are examined over the five hand swab tests. This separate analysis will provide information on whether one of the four classes is subject to a higher level of bacterial contamination.

The distributions of the bacteria for each test over the four activities under study are shown in figure 4.13. Table 4.24 gives a summary of the mean and standard deviation of the number of cfu/cm² of bacteria for each test and activity. The actual results are given in Appendix B2. The table shows that the highest mean number of bacteria appears for the butcheries and the lowest for bakeries. At the beginning all four activities show a decrease in the mean number of bacteria followed again by an increase in the last tests.

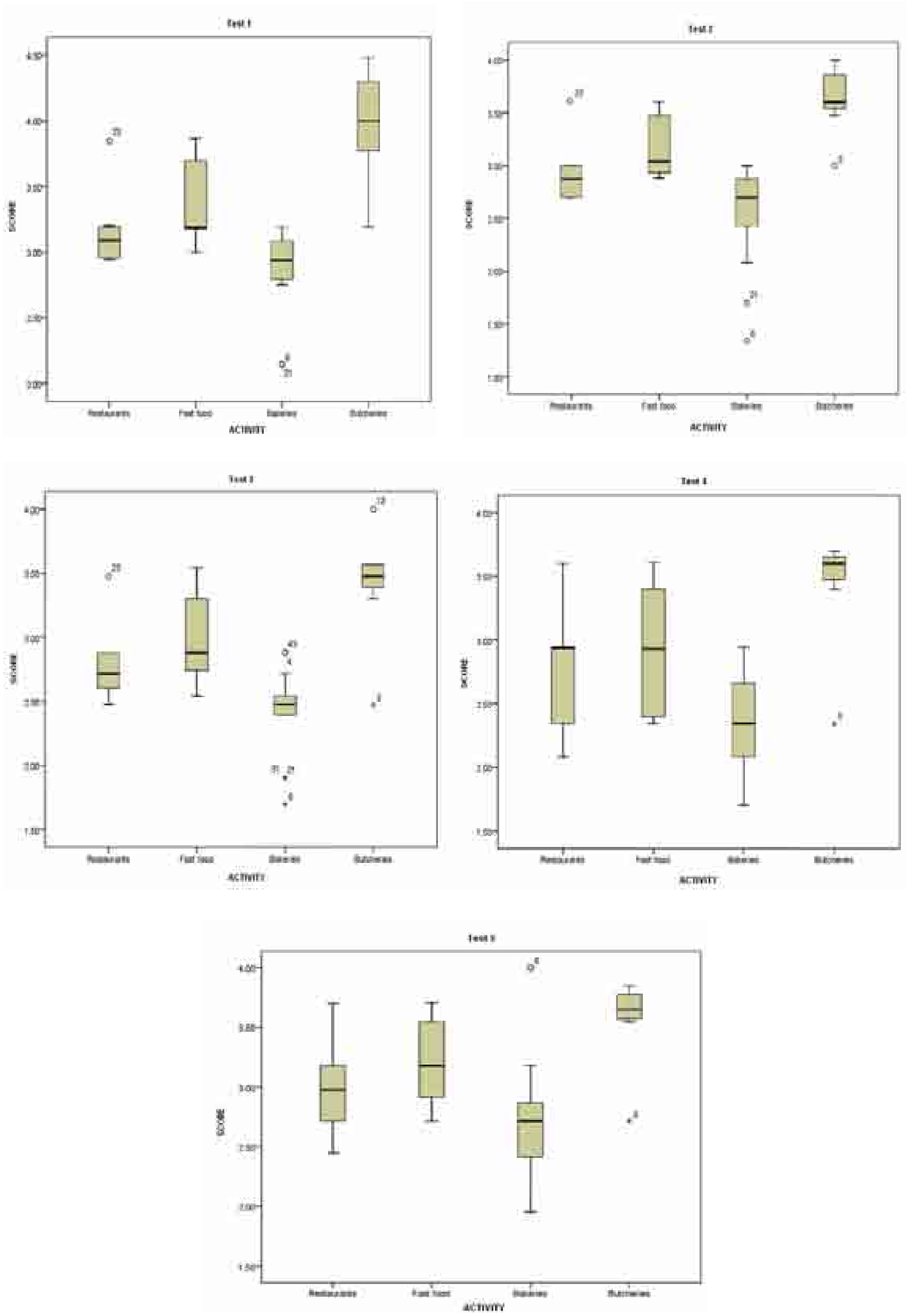

Figure 4-13 Box-and-Whisker plots for bacteria distribution for each class over the five hand swab tests

Activity	Test 1 Mean / sd Log cfu/cm^2	Test 2 Mean / sd Log cfu/cm^2	Test 3 Mean / sd Log cfu/cm^2	Test 4 Mean / sd Log cfu/cm^2	Test 5 Mean / sd Log cfu/cm^2
Restaurants	3.11 ± 0.21	2.88 ± 0.23	2.74 ± 0.23	2.80 ± 0.36	2.97 ± 0.27
Fast Food	3.35 ± 0.35	3.17 ± 0.30	2.98 ± 0.38	2.94 ± 0.51	3.22 ± 0.36
Bakeries	2.87 ± 0.33	2.53 ± 0.48	2.42 ± 0.34	2.38 ± 0.38	2.71 ± 0.49
Butcheries	3.98 ± 0.41	3.63 ± 0.31	3.42 ± 0.43	3.44 ± 0.45	3.57 ± 0.36

Table 4-24 Summary of mean and standard deviation of the level of bacteria on the five hand swab tests

4.5.2 Environmental Samples / Surface Swab Tests

As described in chapter 3, section 3.7.3.1, for the surface swab tests, 1 swab sample was taken from each enterprise in different levels (table 3.1) giving 50 surface swab samples. Test 1 was performed in level 1, test 2 in level 2, test 3 in level 4, test 4 in level 6, and test 5 in level 8 (table 3.1). Butchers expected to have higher level of contamination as they are dealing with raw food compared to those dealing with cooked food.

TEST (n = 50)	MEAN ($\log_{10}$cfu/cm^2)
1	3.21 ± 0.42
2	2.78 ± 0.56
3	2.68 ± 0.46
4	2.87 ± 0.46
5	2.96 ± 0.44

Table 4-25 Mean and standard deviation for the five surface swabs tests

An exploratory analysis and tests for the normality of the data for the surface swab tests were performed as before. The results on the transformed logarithmic data (Appendix B1), indicated that normality has not been achieved therefore non-parametric tests were used for differences between the five tests. The descriptive statistics for the 5 surface swab tests are shown in table 4.25.

The table shows a drop in the average number of bacteria (cfu/cm²) from the first test to the second and further in the third test, followed by a small increase in the fourth and fifth tests. To test the normality of the data box-and-whisker plots are presented in figure 4.14. In the box plot the circles and stars represent outliers, that is, extreme values of the data. Kolmogorov-Smirnov and Shapiro-Wilk normality tests are given in table 4.26.

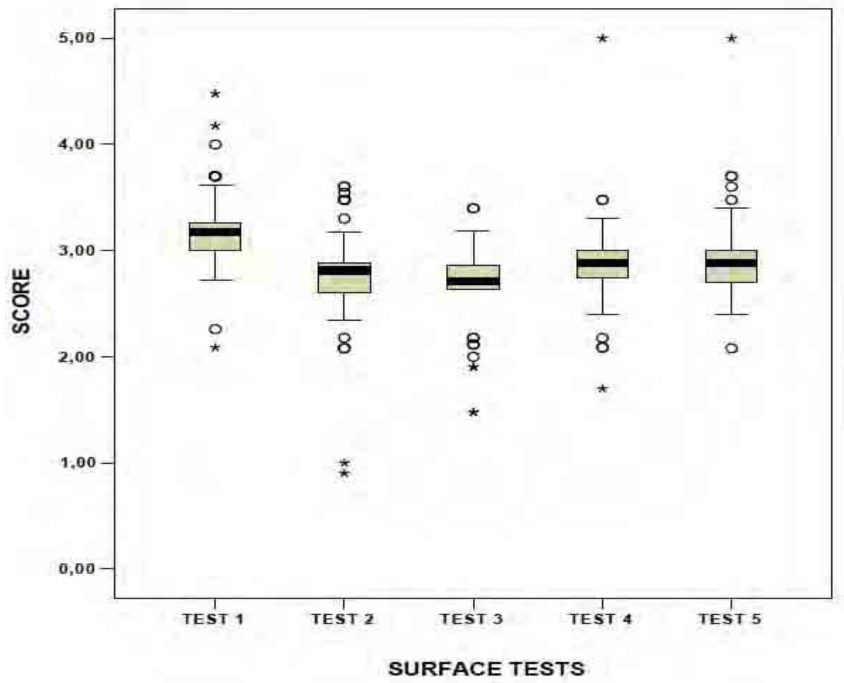

Figure 4-14 Box-and-Whisker plots for the surfaces swab tests

SURFACETEST	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TEST 1	.236	50	.000	.932	50	.006
TEST 2	.210	50	.000	.879	50	.000
TEST 3	.257	50	.000	.906	50	.001
TEST 4	.189	50	.000	.829	50	.000
TEST 5	.226	50	.000	.838	50	.000

a. Lilliefors Significance Correction

Table 4-26 Normality tests for surface swab tests

As shown in both the box-and-whisker plots and the normality tests performed on the transformed logarithmic data, normality has not been achieved therefore non-parametric tests were used to check for differences between the five tests. The Kruskal-Wallis test performed gives a *p*-value of 0.000 (<0.05) (table 4.27) which is highly significant and indicates that there are significant differences between the surface tests in the five levels. This means that there was an improvement at the beginning due to the training on PRPs and the positive attitude of the personnel.

Test Statistics[a,b]

Chi-Square	47.347
Df	4
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: SURFACETEST

Ranks

SURFACE TESTS	N	Mean Rank
TEST 1	50	181.03
TEST 2	50	105.39
TEST 3	50	88.13
TEST 4	50	121.70
TEST 5	50	131.25
Total	250	

Table 4-27 Kruskal Wallis test for the surfaces swab tests

	Compare Test2:Test1	Compare Test3:Test2	Compare Test4:Test3	Compare Test5:Test4
Z^a	-4.644	-.936	-2.676	-.591
Asymp. Sig	.000	.349	.007	.554

Table 4-28 Mann-Whitney test for surfaces swab tests

The Mann-Whitney non-parametric test for independent samples was applied to check how the surface analyses tests change over successive tests. The results are shown below in table 4.28. Actual calculations are given in Appendix B1.

Using the Bonferroni correction the critical value is 0.05/4=0.0125. The results of the above tests show no significant differences between surface tests 2 and 3 and 4 and 5 (p>0.0125) and significant differences between surface tests 1 and 2, and 3 and 4.

4.5.2.1 Analysis by Activity of Enterprise

In what follows an examination of surface swab tests by the activity of an enterprise is performed since the different enterprises were subject to a different level of bacteria. This separate analysis will provide more information. The distributions of bacteria for each test are shown in figure 4.15 and a summary of the mean and standard deviation of the level of the bacteria in log cfu/cm^2 are given in table 4.29. Actual results are given in Appendix B1. Table 4.29 shows that the highest number of bacteria appears for the butcheries and the lowest for bakeries. For all four activities there is at the beginning a decrease in the mean number of cfu of bacteria followed again by an increase in the last tests.

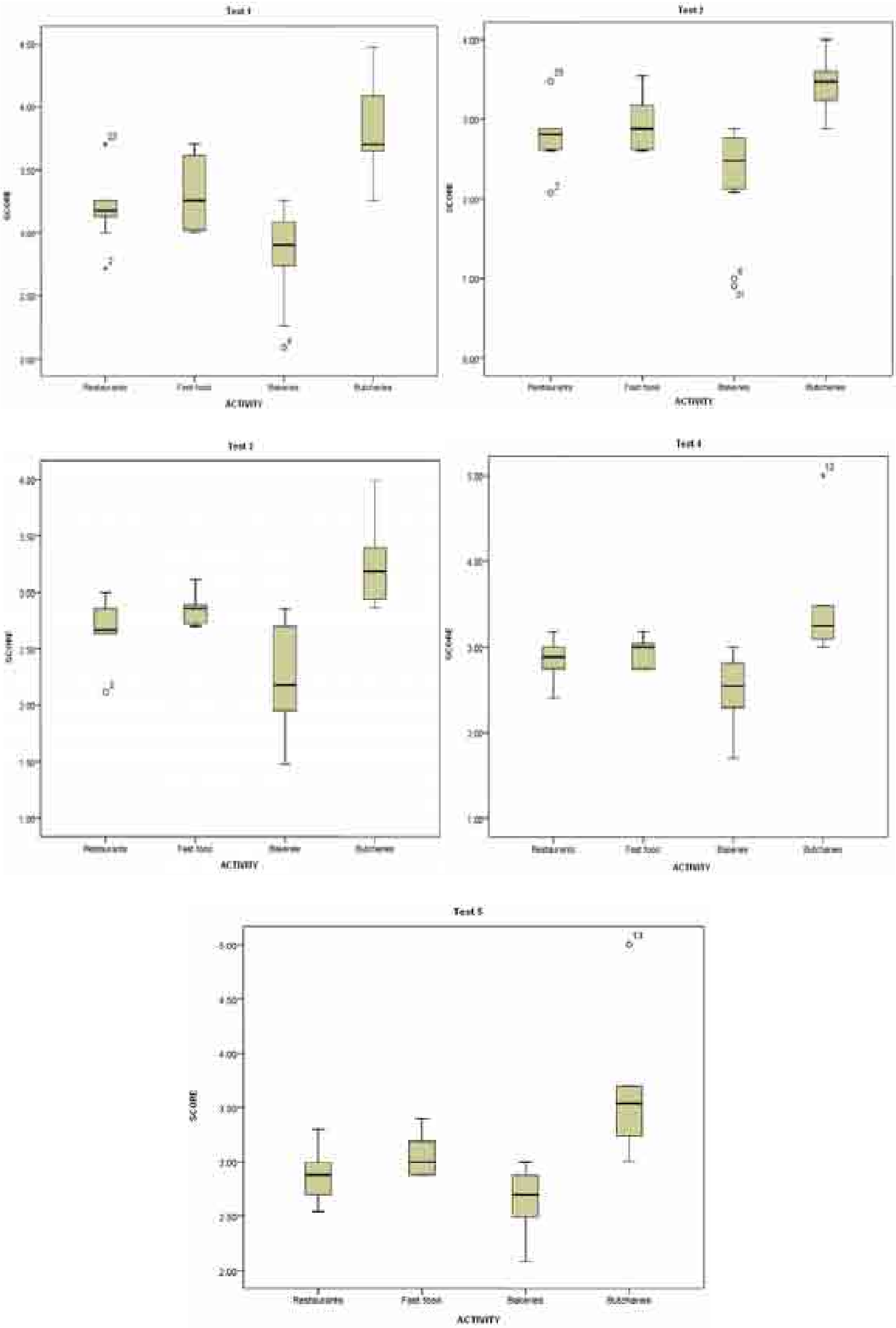

Figure 4-15 Box-and-Whisker plots for bacteria distribution for each activity on the five surface swab tests

Activity	Test 1 Mean / sd (log_{10}cfu/cm^2)	Test 2 Mean / sd (log_{10}cfu/cm^2)	Test 3 Mean / sd (log_{10}cfu/cm^2)	Test 4 Mean / sd (log_{10}cfu/cm^2)	Test 5 Mean / sd (log_{10}cfu/cm^2)
Restaurants	3.17 ±0.18	2.78 ±0.26	2.70 ±0.19	2.86 ±0.17	2.85 ±0.18
Fast Food	3.31 ±0.29	2.96 ±0.36	2.86 ±0.14	2.96 ±0.18	3.07 ±0.21
Bakeries	2.86 ±0.33	2.33 ±0.62	2.26 ±0.48	2.51 ±0.39	2.68 ±0.28
Butcheries	3.83 ±0.38	3.44 ±0.33	3.24 ±0.37	3.45 ±0.65	3.62 ±0.61

Table 4-29 Summary of mean and standard deviation of the level of bacteria (log_{10} cfu/ cm^2) on the five surface swab tests

4.5.3 Food Analyses

Each food evaluation included five food samples depending on the enterprise's high risk foods as explained in chapter 3, section 3.7.3.2. A plan for the food analyses for each enterprise was prepared in collaboration with scientists from the laboratories conducting the analyses as part of the enterprise HACCP plan. The food analysis plan was based on the high risk foods and incoming products of each of the enterprises as well as the CCPs that were under control. According to the food analyses plan the number of food samples for each enterprise was 5 each from different products. The five food analyses FA1, FA2, FA3, FA4, and FA5 were performed in levels 1, 2, 4, 6, 8 respectively. The total number of food samples was 250 in each of the five levels. The laboratory indicated a violation for each non conforming food sample.

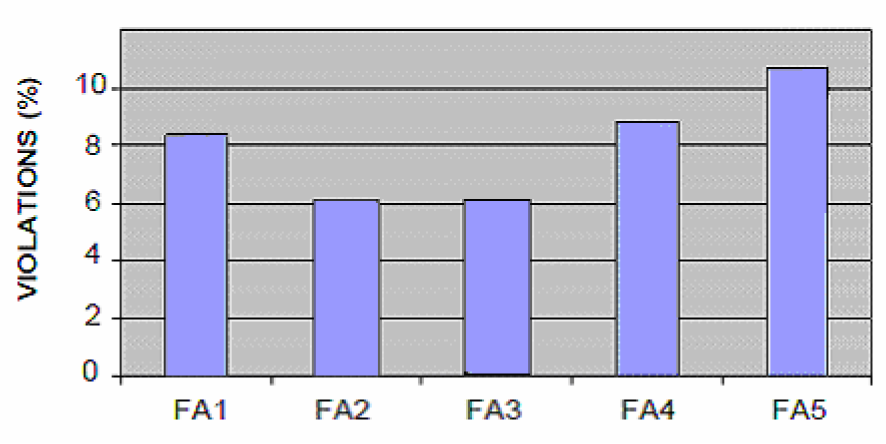

Figure 4-16 Violations over the five food analyses

Figure 4.16 shows a drop from an 8.4% in violations in the first analysis (FA1) to 6% in the second (FA2), which remains the same in the third (FA3) but in the 4th analysis (FA4) there was an increase to 8.8% and a further increase in the fifth analysis (FA5) reaching 10.8% of violations.

4.5.3.1 Analysis by Activity of Enterprise

A further analysis is performed on the food analyses by activity. Table 4.30 gives the numbers of violations (for pathogens and indicators) for each activity over the five food test analyses. It can be noted from table 4.30 that the number of violations increased from Analysis 1 to Analysis 5. That was due to the negative attitude of the personnel resulting from the complexity of the system.

	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Analysis 5
Restaurants	8	8	8	9	9
Fast Food	1	1	1	2	3
Bakeries	6	3	4	6	8
Butcheries	6	3	2	5	7

Table 4-30 Number of violations of food analyses by activity

Analysis	Significance
1	0.67
2	0.236
3	0.322
4	0.361
5	0.152

Table 4-31 Chi-Square results for food analyses

To check for a significant difference between violations in food analyses and activity, a chi-square test was used. Table 4.31 gives the significance of each of the five food analyses. Actual results are given in Appendix B3. The results indicate that there is no significant difference in any of the analyses over the five tests.

4.5.4 Water Analyses

For the water analyses one water sample was included from each enterprise as described in section 3.7.3.3, giving 50 water samples for each of the five tests. Test 1 was performed in level 1, test 2 in level 2, test 3 in level 4, test 4 in level 6, and test 5 in level 8 (table 3.1). Each test consisted of a microbiological and a chemical analysis to check the quality of the water. Standards used to determine compliance were explained in chapter 3, section 3.7.3.3.

4.5.4.1 Microbiological Analyses

Five microbiological analyses were performed (MA1-MA5), and the percentage violations are shown in figure 4.17.

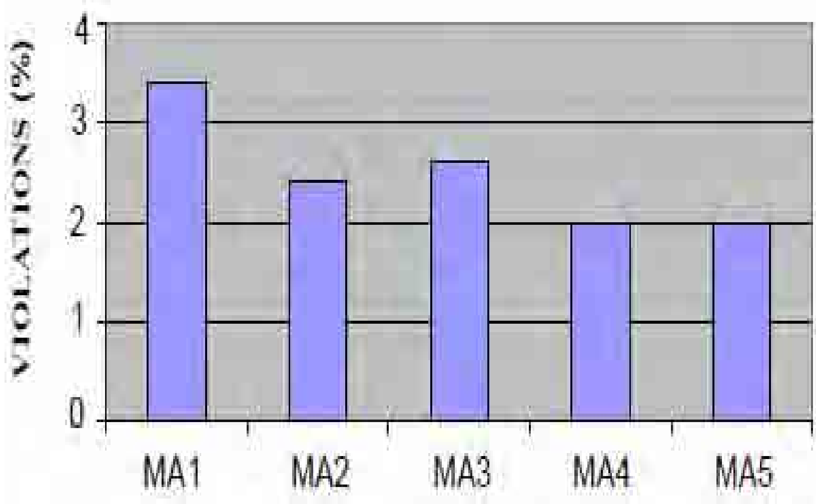

Figure 4-17 Violations over the five microbiological water analyses

In the first water analysis there were 17 violations which dropped to 12 in the second, 13 in the third and dropped further to 10 in the last two analyses.

4.5.4.2 Chemical Analyses

The results of the chemical water analyses CA1-CA5 are shown in Figure 4.18.

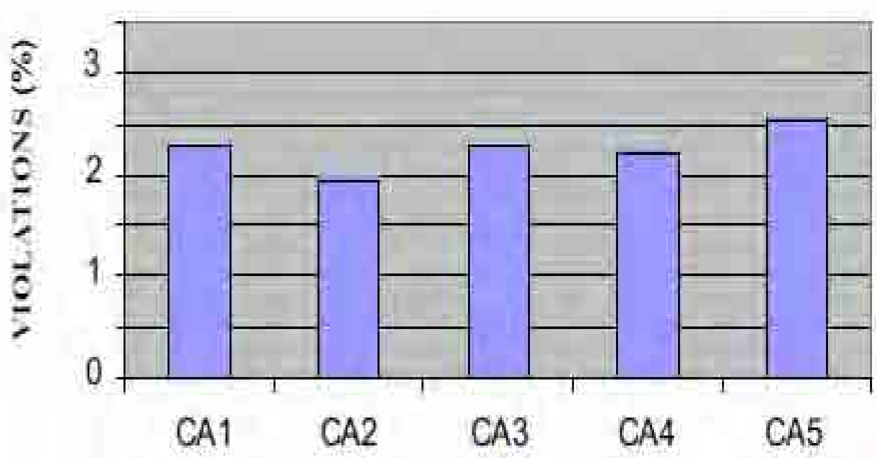

Figure 4-18 Violations over the five chemical water analyses

The percentage results in the bar chart indicate a small change in the number of violations, starting with 2.2%, fell to 2% in the second water analysis, increased to 2.2% in the third and forth analyses, and ended up with 2.6% violations in the last analysis.

4.6 Analysis of Employees' Tests

In what follows an analysis of the employees' tests (Appendix C) is performed. The Wilcoxon's signed rank test and the Friedman's test are used for the analysis of the employees' tests.

As discussed in chapter 3, section 3.7.4, through the employees' tests the knowledge of all personnel involved in the implementation of the system were examined. Three tests, Test1, Test2, and Test3, were performed in levels 1, 2 and 6 respectively (table 3.1). Part A was the same for all three tests and Part B was different based on the training of the employees and the complexity of the system (Appendices C1-C3).

4.6.1 Analysis of Part A of the Test

The data for part A for each company represents the total score gained by its employees (N = 438) who were tested in five questions with 2 marks each. The same set of questions was asked in all three tests. The mean scores for the 3 Parts A (A1-A3) of Test1-Test3 together with the standard deviation and the range are given in the table 4.32.

	Mean	Standard Deviation	Minimum	Maximum
PART A1	3.97	.73	2.50	6.36
PART A2	8.59	1.11	5.67	10.00
PART A3	9.41	.70	7.78	10.00

Table 4-32 Descriptive measures for Part A of the employees' test

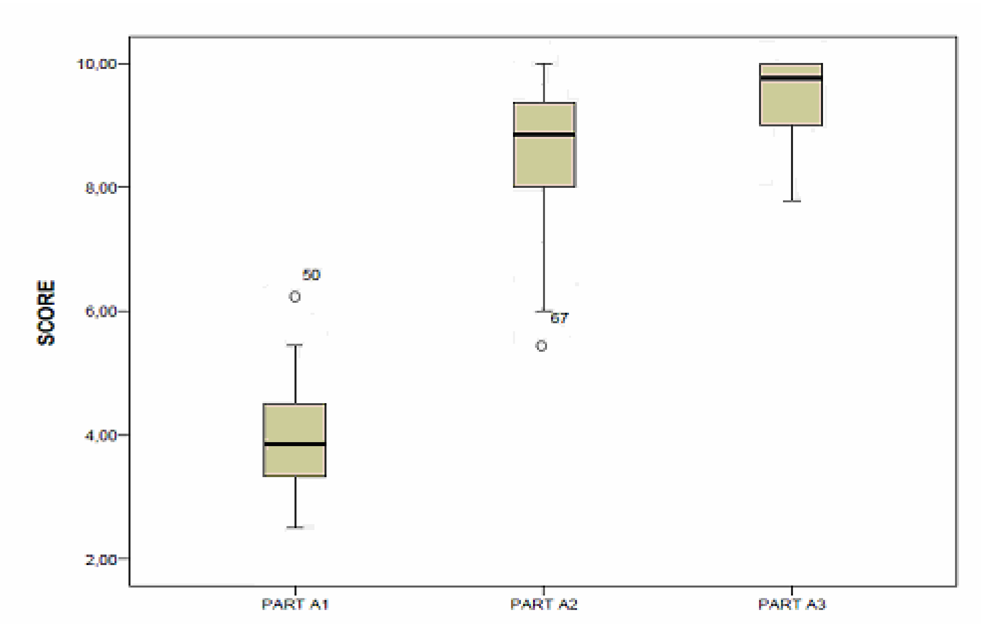

Figure 4-19 Box plots for Parts A1-A3 of the employees' tests

One can see that the mean score more than doubled between parts A1 and A2, and increased further between parts A2 and A3. The distributions of the three sets of data are shown in the box plots in figure 4.19.

In order to test for significant differences between parts A1, A2, and A3, Friedman's test was used. In order to test for differences between successive parts the Wilcoxon's signed rank test was used. Friedman's test has a *p*-value of 0.000 which is clearly highly significant (table 4.33).

Test Statistics[a]

N	50.000
Chi-Square	91.033
df	2.000
Asymp. Sig.	.000

a. Friedman Test

Table 4-33 Friedman's test for Part A of the employees' test

Test Statistics[b]

	A2 - A1
Z	-6.156[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	A3 –A2
Z	-4.641[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Table 4-34 Wilcoxon signed rank test for Part A of the employees' test

The Wilcoxon's signed rank test for Parts A1 and A2 gives a *p*-value of 0.000 indicating the significant increase observed between the two parts. A significant increase is also obtained for parts A2 and A3 (table 4.34). The critical value is 0.025.

4.6.2 Analysis of Part B of the Test

The data for Part B for each company represents the total score gained by its employees who were tested in a multiple choice test with different questions in each part. The maximum score for each of the three Parts B (B1-B3) was 10 marks. The exploratory analysis again shows skewed distributions which are presented in figure 4.20.

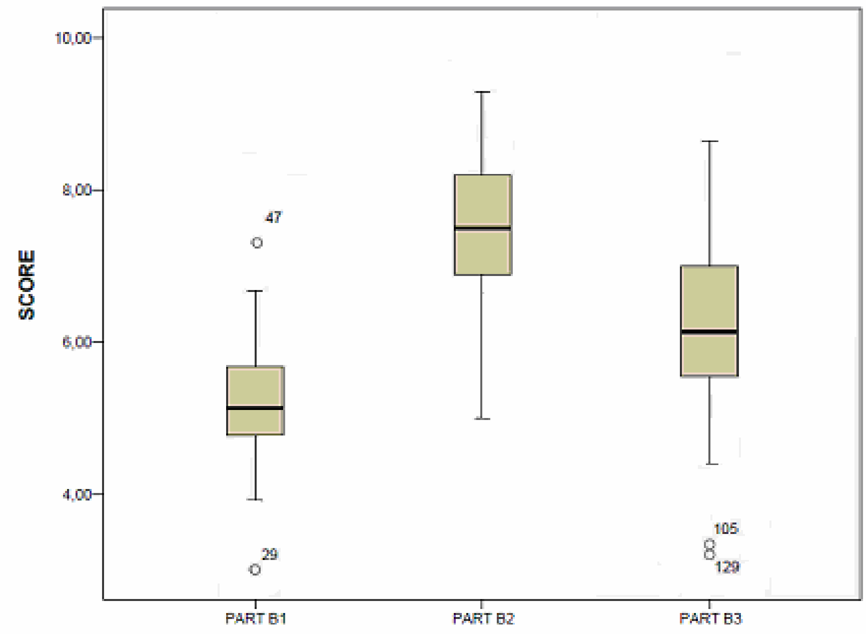

Figure 4-20 Box plots for Part B of the employees' test

The mean scores for Parts B1-B3 together with the standard deviation and the range are presented in the table 4.35.

	Mean	Standard Deviation	Minimum	Maximum
PART B1	5.23	0.78	3.00	7.25
PART B2	7.49	0.96	5.00	9.00
PART B3	6.16	1.22	3.50	8.50

Table 4-35 Descriptive measures for Part B of the employees' test

4.7 Total Cost

In table 4.36 the range of the costs is presented. The first column gives the cost of the implementation for consultation and training of the HACCP system. The second column gives the cost of the changes to the building and facilities that each company was obligated to do according to the requirements of the PRPs as described in 3.7.5. From the table the cost for implementation ranges from €3000 to €27000 and for building and facilities the cost ranges from €1200 to €30000.

Enterprise	Cost of Implementation (€)	Cost of Building and Facilities (€)	Enterprise	Cost of Implementation (€)	Cost of Structure (€)
1	10000	30000	**26**	9800	10450
2	8900	10000	**27**	4100	3987
3	6000	7898	**28**	3000	7300
4	15000	23565	**29**	5500	8300
5	9800	12000	**30**	5800	9200
6	7000	18000	**31**	9500	10500
7	4000	8500	**32**	24500	10600
8	9500	12300	**33**	27000	21400
9	5900	10895	**34**	22800	19800
10	14000	25679	**35**	24900	21000
11	15700	19500	**36**	3900	9600
12	20000	20600	**37**	6800	16500
13	23000	21786	**38**	10000	15000
14	14000	20797	**39**	5500	17800
15	8500	14900	**40**	5400	8500
16	22000	18695	**41**	5600	12900
17	3900	8030	**42**	9800	11500
18	4000	6500	**43**	20000	17900
19	9900	9900	**44**	9800	19000
20	3800	7500	**45**	24800	21798
21	7200	6300	**46**	5500	9800
22	5800	11900	**47**	3500	9100
23	25000	23000	**48**	3000	1200
24	8500	14600	**49**	8300	9500
25	6800	9500	**50**	10500	13800
			Average	**10750**	**10896**

Table 4-36 Costs for implementation and infrastructure of the 50 enterprises

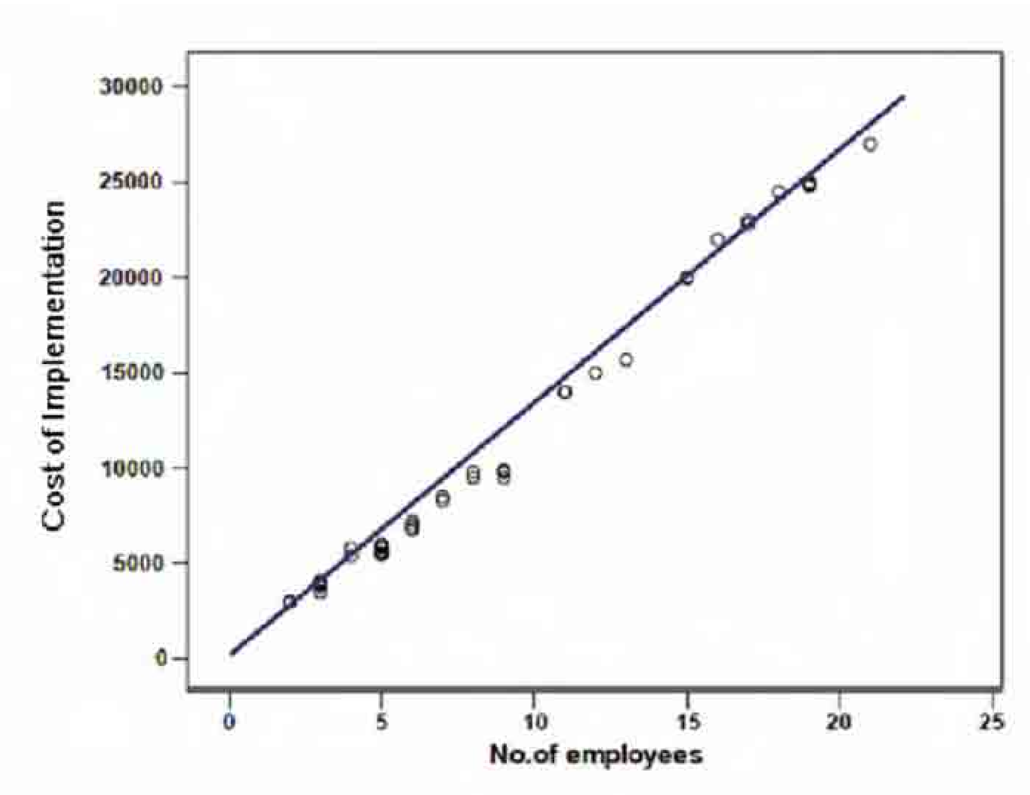

Figure 4-21 Plots of the no. of employees vs cost of implementation / cost of buildings and facilities

To analyze the relationship between the number of employees in an enterprise and the cost of the implementation (consultation and training) / cost of building and facilities for an enterprise when applying the HACCP system the two are plotted against one another. At the same time a best fit line is obtained (figure 4.21). In order to obtain and analyse the costs, data were collected from the enterprises. The collection of data regarding cost of building and infrastructure was difficult as the documents were internal and confidential for each enterprise. The cost of implementation only included consultation fees. The enterprises had additional costs due to the time spent (2 hours daily) in order to fill the documents and records.

Looking at the first plot (figure 4.21), it can be seen that as the number of employees increases, the cost for application of the system for an enterprise increases, as (i) the more the employees in an enterprise the more people are involved in the implementation of the system, and (ii) procedures are more complicated. The size of the company is considered proportional to the number of employees, and so the cost of the application of the system is proportional to the size of the enterprise. The relationship between the two variables "No of employees", plotted on the *x*-axis, and "Cost", the dependent variable plotted on the *y*-axis, is to be very close to a straight line so a linear model is assumed. Using linear regression analysis the regression line takes the form:

$$y = 1253x\,.$$

This equation suggests that the additional cost for every extra employee in the enterprise will be approximately €1250. The cost for each employee includes

- training expenses;
- on-the-job training concerning the understanding and implementation of the system;
- involvement in HACCP system procedures;
- all medical analyses for personal hygiene required by HACCP system.

In order to check how well the model fits the data an *R*-squared and ANOVA (Analysis of Variance) tests were used. The results are shown in tables 4.37 and 4.38.

Model Summary

Model	R	R Square [a]	Adjusted R Square	Std. Error of the Estimate
1	.996[b]	.991	.991	1198.84265

a. For regression through the origin
b. Predictors: No. of employees

Table 4-37 Summary statistics for the cost of implementation of the system

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	8.190E9	1	8.187E9	5696.626	.000[a]
	Residual	7.042E7	49	1437223.698		
	Total	8.260E9[b]	50			

a. Predictors: No. of employees
b. Total sum of squares is not corrected for the constant
c. Dependent Variable: Cost
d. Linear Regression through the origin

Table 4-38 ANOVA model fit for the cost of implementation of the system with respect to the number of employees

The large value of variable *R* (0.996) in table 4.37 indicates a very strong linear relationship between the variables and the *R* -squared variable (0.991) indicates a high predictive power of the linear equation. The ANOVA test gives a significance value of the *F* statistic 0.000 (<0.05) (table 4.38) indicating that the independent variable (size of the company) does a very good job explaining virtually all (99.1%) of the variation of the dependent variable i.e. cost.

Looking at the second plot (figure 4.21), it can be seen again that as the number of employees increases the cost of infrastructure increases almost linearly. Even thought the cost in this case shows to be high, the infrastructure changes that took place were a physical improvement for the companies. The analysis focuses on the cost of implementation due to better access to data and due to the fact that these costs had to do with the consultants.

5 DISCUSSION

HACCP is a system for ensuring the safety and suitability of food for human consumption. As mentioned in chapter 2, HACCP roots go back to the end of the 1950s in the laboratories of NASA, where a preventive Hazard Analysis and Critical Control Point (HACCP) system was developed (Bauman, 1995). The HACCP system ensures the production of a safe product by controlling the food safety hazards. The necessity of applying such a system led the European parliament to mandate all food operators to comply with HACCP through the regulation for the Hygiene of Foodstuffs (EC) No 852/2004.

After Cyprus successfully joined the European Union in 2004, its legislation had to be harmonized with the relevant European legislation. HACCP has been a legal requirement in Cyprus food industry since 2004. The Minister of Commerce, Industry and Tourism in Cyprus stated that any food enterprise that does not comply with the European Regulation will be closed down (Nicolaou, 2003). In order to fulfill the requirements of the European food regulation, food enterprises needed to implement a HACCP system. The government funded the implementation of food management systems up to 40% of the costs (Vasiliou, 2003b). In order for an enterprise to get the funding they needed to present a HACCP certificate. To obtain this certificate, enterprises had to implement a standard. Only certification bodies could conduct the third party audit and issue the certificate. The financial benefit was the main motivation for an enterprise to implement the food management systems and apply the standards. In addition, there is an anecdotal element of the increased customer satisfaction and profit resulting from the implementation of such a system that motivated to a lesser degree the companies.

This chapter will discuss whether the implementation of food safety management systems improved the hygiene and food safety in SMEs in Cyprus. Food safety management systems include the application of PRPs, the implementation of HACCP principles, implementation of the national standard CYS244, and finally the implementation of the international standard ISO22000. The outcomes of SMEs' attitudes, knowledge, hygiene practices, cleaning, food safety, and cost barriers, experienced during the implementation of the food safety management systems, are discussed, based on the results obtained and presented in chapter 4.

5.1 Sample under Study

The sample under study consisted of 50 SMEs from the researcher's working background that agreed to take part in the research. Cyprus economy is dominated by SMEs which constitute 99.9% of all enterprises. The majority of these SMEs (95%) employ less than 10 persons (Ministry of Commerce, Industry and Tourism, 2005). The four classes of enterprises by activity under study are restaurants, fast foods, bakeries, and butcheries, with a total number of 3770 enterprises (Statistical Service of Cyprus, 2005).

As mentioned in chapters 1 and 3, the Cyprus food industry and especially SMEs have low staff turnover as they are family owned that are transferred from generation to generation. That was an advantage for the research, as the sample size was stable. The low turnover represents stability, making investments in management attractive and SMEs positive in implementing the food management systems. As stated in the literature, one of the main problems of implementing HACCP in food businesses is the high staff turnover rate (Acosta, 2009; Bas *et al*., 2006). The turnover of SMEs in Cyprus has not been calculated, and in the researcher's knowledge has not been calculated in any study to date. At the beginning of the research, SMEs were motivated in applying good hygiene practices and in participating in the research. At the end of the study, as discussed later in the chapter, SMEs developed a negative attitude towards the food management systems.

5.2 PRPs, HACCP and integration with CYS244 and ISO22000 standards

As discussed in the methodology chapter, development of PRPs, HACCP, CYS244, and ISO22000 standards were conducted in each enterprise through different levels (table 3.1). This section analyses the effect of PRPs, HACCP, CYS244, and ISO2000 standards in the enterprises' hygiene practices, attitude, environmental and food safety, and knowledge.

5.2.1 Hygiene Practices

The need to monitor food handling practices to protect customer's health by ensuring food safety is well documented in the literature (Giampaoli *et al.*, 2002). As defined in chapter 3 an audit is a systematic document used to obtain evidence that can be evaluated to show if the requirements have been followed (Burau, 2007).

In what follows, the results of hygiene practices through the audit are analysed. Audits were carried out to assess the hygiene and cleaning practices. The audit sheet was divided into 5 parts: part A "building and facilities", part B "cleaning and disinfection", part C "production and process control", part D "performed evaluations", and part E "HACCP system documentation". A limitation of the audit checklist used is the possibility to have missed some potential problems and also to have overlooked some potential important parameters. No such limitations were identified through the study. Data was obtained from the researcher's observations. Thus, data may be considered more representative than by using a self directed questionnaire.

5.2.1.1 Audit before any intervention and after PRPs

All 50 enterprises applied the PRPs. The results of the audit after the completion of the application of PRPs will be compared to the results of the audit before any intervention.

Audit 1 was conducted before any intervention and the results were compared to Audit 2 results, after completion of the application of PRPs. The audit checklist was designed to measure changes to the level of hygiene practices. After PRPs a significant difference was found between Audits 1 and 2 in all 4 parts of the audit. Part E wasn’t applicable in that level.

Concerning part A, “building and facilities”, the results of the audit checklist show an increase in the mean scores between Audits 1 and 2 from 10.82 to 25.00 (chapter 4, table 4.2). After PRPs, a comparison between Audit 1 and Audit 2 reveals a highly significant difference, (table 4.4, chapter 4). As mentioned before, Audit 1 was performed before any intervention and Audit 2 after changes in building and facilities and implementation of PRPs. Thus, this difference between the results of the two audits was expected.

Major changes and improvements were observed in the structure of premises after application of PRPs. Of these premises 25 needed to change their working surfaces to stainless steel, to allow for the surfaces to be cleaned and sanitised easier, and 8 of them needed to separate the area of hot and cold preparation. Ten of the premises had no suitable and sufficient equipment for hand washing with the appropriate labeling in the production area. That was a barrier for the staff’s hand washing, resulting in increased hazards from microbiological contamination. As stated in the literature, poor hand washing practices can cause spread of microbial contamination outbreaks (Giampaoli *et al.* 2002; Green *et al.*, 2006; Montville *et al.*, 2001). Hand washing before handling and preparing food is recommended by hygiene guidelines (FSA, 2005). FDA reported improper hand washing by employees in 73% of food services (Selman, 2006). At the end of PRPs, 8 of the premises added at least one hand washing facility furnished with paper, soap and the appropriate labelling. One of the enterprises, producing traditional sweets, was operating in an area which was part of the owner's house. Since this premise did not fulfill most of the requirements, it was decided that an independent premise needed to be built according to the requirements of the legislation and PRPs.

A common thing needed to be done by all of the enterprises was to cover the production area windows to the outside with fine mesh screens. None of the premises had these window screens before the implementation of PRPs, something that is needed to prevent pests from entering in the production area. Concerning food safety, pests are considered a physical hazard for foodstuffs and must be excluded from the plant (FSIS, 2002). With the completion of the PRPs all premises added the necessary window screens.

Concerning the equipment for the food preparation and utensils, all of the premises had some utensils made of wood that had to be replaced with stainless steel utensils. A stainless steel surface has been recommended in the industry due to its strength and non corrosive properties (Kusumaningrum *et al.*, 2003). Most of the premises (40) didn't have the appropriate colored chopping boards (green for vegetables, red for meat, etc.) and as a result they were using the same chopping board to cut all food stuffs. That was increasing the cross contamination resulting in a microbiological hazard for food. Surface cleaning is important since bacteria harboring on the surfaces can lead to contamination of other surfaces and food products (Beumer and Kusumaningrum, 2003).

Government auditors advised 2 of the enterprises to add an extra rest room based on the number of their employees. They also advised 3 enterprises to change their solid floor into a poured resin one in order to be cleaned and dried easily. These changes were expensive, time consuming, and in the researcher's opinion unnecessary, as the floor of the premises was a perfectly good solid floor. PRPs requirements specify the need for a floor that can be cleaned and dried easily, but does not specify exactly the type of the floor.

Concerning part B, "cleaning and disinfection", a major improvement was observed. The mean scores show an increase from Audit 1 (12.04) to Audit 2 (17.84) (chapter 4, table 4.5). After the training on PRPs in level 2 (table 3.1), there were changes and improvements regarding cleaning and disinfection. Most of the personnel working in the enterprises, initially before any intervention, had a poor knowledge of the cleaning and disinfection procedures. Walker *et al.* (2003) reported poor knowledge of cleaning and disinfection procedures in many businesses. During the training personnel were given explanations on the importance of cleaning, concerning bacterial cross contamination. As stated in the literature, cleanliness was reported to be the most important control in preventing foodborne illnesses (Worsfold and Griffith, 2003). During the on the job training session, correct ways of hand washing and cleaning of working surfaces were illustrated. Personnel indicated that they understand the way of cleaning and they made an extra effort with the cleaning. Improvement was also made in the use of the sanitation chemicals as 47 of the enterprises started using professional chemicals to clean their premises. Training was provided on the approved sanitation chemicals and on how to use them in an appropriate way.

Before PRPs most of the enterprises had bins uncovered in the production area. Due to time limitations, personnel preferred the bins uncovered as they didn’t have to cover and uncover them every time they had to throw away any garbage. After implementation of PRPs there was an improvement in personal hygiene as well. Most of the employees stopped wearing jewelry and started wearing head coverings. With the use of the head coverings food is protected from being contaminated by fallen or touching hair. After PRPs personnel stopped entering the production area when they had illnesses, infections or injuries. Only 3 of the premises kept sickness records before the implementation of PRPs. Most of the enterprises stated that this was due to time constraint or the lack of appropriate information from the employees.

After the implementation of PRPs an improvement was made to pest control, as all of the enterprises purchased pest control contracts by professional external pest control services. The bait stations, the chemicals used, and the documentation, were all provided and controlled by the pest control companies.

Concerning part C, “production and process control”, there was a highly significant difference between Audits 1 and 2 (chapter 4, table 4.10). Mean scores show an increase from Audit 1 to Audit 2 from 11.64 to 13.06 (table 4.8) due to the positive attitude among the enterprises and the continuous improvement during the implementation of PRPs. All enterprises were positive at the beginning about applying food management systems and were willing to perform the required changes in their procedures. Some of the procedures, including first-in-first-out storage and the correct defrosting of the food, had already been used by the enterprises before the application of PRPs. An improvement was observed in the inspection procedure of the incoming products. Enterprises started inspecting incoming products for any damages, contamination, and temperature, and non-conforming ones were rejected.

The importance of temperature control in food industry is well documented in the literature. Gillespie *et al.* (2000), in a study conducted in UK catering establishments, showed that food stored above 8˚C was likely to be microbiologically unsatisfactory. In particular, industry guides and regulations require chilled products to be stored in temperatures of 8˚C and below (Anon, 2006; Gillespie *et al.*, 2000). Adams and Moss (2000) stated that low temperatures (<8˚C) can slow down bacterial growth. As observed by Walker *et al.* (2002), SMEs are often unable to monitor delivery temperature. In order for an enterprise to conduct a proper temperature monitoring, it is necessary to have a calibrated thermometer. Henroid and Sneed (2004) state that poor calibration of thermometers results in use of an inaccurate temperature by food service operations. A fridge thermometer is essential in monitoring temperature of equipment. The literature reports a high percentage of food establishments do not own a fridge thermometer (Gianpaoli *et al.*, 2002; Kennedy *et al.*, 2005; Towns *et al.*, 2006).

During the theoretical part of the training, personnel were informed on the importance of temperature control for delivery, storage, cooking and display. From the study sample, it was found that 15 of the enterprises didn't have thermometers at all and the rest didn't have calibrated thermometers. Enterprises made contracts with external laboratories for the calibration of their thermometers. At the end of PRPs all of the enterprises had the required calibrated thermometers.

Twenty five of the enterprises had fridge thermometers but only 3 of them had temperature records available. Henroid and Sneed (2004) reported that most food businesses did not record food temperatures when measured. After implementation of the PRPs, 35 of the enterprises had available records for fridge temperatures. This was a major improvement as temperature is one of the major causes of microbial multiplication and it is essential to maintain the food temperature from delivery to display (Cates *et al.*, 2006; Adams and Moss, 2000). In Cyprus due to the Mediterranean weather and especially in summer time, with very high temperatures, proper storage is essential.

Before the implementation of PRPs, none of the enterprises maintained the required cooking temperature when cooking their food products. The cooking temperature is critical as it has to be 75˚C or above to kill common pathogens (FSA, 2005). Personnel working in the production area did not seem to understand the importance of monitoring the cooking temperature as no improvement was made after implementation of the PRPs. During the training a danger zone (8-63˚C) temperature diagram of the bacterial growth was presented. Adams and Moss (2000) indicated that the optimal growth for bacteria is around 35-37˚C. Due to time limitations personnel relied food cooking on experience and visible inspection. Employees stated that is very difficult, especially in a busy day, to monitor all these temperatures including delivery, storage, cooking, and display temperatures. None of the enterprises were monitoring the hot holding temperatures (>63˚C). Four of the enterprises were holding food below the recommended temperatures. After the implementation of PRPs only 2 of the enterprises refused to monitor the hot holding temperatures.

Concerning part D, “performed evaluations”, table 4.13 shows a highly significant difference between Audits 1 and 2. This significant difference was expected due to the fact that before the beginning of the implementation of the system the enterprises did not perform any analyses since, as they mentioned, they thought these laboratory analyses were not important. The increase in the mean scores from Audit 1 to Audit 2 (table 4.11) was due to the fact that enterprises began to perform the laboratory analyses after implementation of the PRPs. However, 15 of the enterprises started of perform the laboratory analyses but all of the enterprises claimed the costs of carrying out the analysis was a barrier, and queried the need for doing them. No one had asked them to perform these analyses before. Laboratory analyses were carried out on food, water, working surfaces, and personnel’s hands. The water analysis was carried out to assess the quality of water the premises used for the production of food. The working surfaces analyses were carried out to assess and validate the cleaning and disinfection, and personnel’s hands analyses were carried out to assess the personal hygiene of the employees.

The food analyses were carried out to assess the safety of the food concerning the microbiological hazards. All laboratory analyses were performed by accredited laboratories. The laboratories undertook the collection of the samples, performed the analyses, and reported the results. Laboratory scientists collected the samples as described in section 3.7.3, chapter 3. Food, surfaces, and hand analyses were carried out on a monthly basis, and the water analyses every three months at the beginning, and later on a yearly basis. Problems associated with water had to do with storage rather than the quality of water since all the necessary microbiological analyses were performed from the General State Laboratory prior to its supply to the premises. Results revealed storage problems in 2 of the enterprises that were using very old tanks to store water. During summer time in Cyprus water supply occurs only two or three times a week due to drought and shortage of water reserves, thus a proper storage is essential. The importance in water storage forces government auditors to expect enterprises to carry out frequent water analyses. The results of the above analyses are discussed later in this chapter. It must be mentioned that prior to the implementation of the food management systems laboratory analyses were optional.

5.2.1.2 Audit PRPs / HACCP

All 50 enterprises implemented PRPs and moved on to the implementation of the HACCP system in level 4 (table 3.1, chapter 3). In this section the results of Audit 3 for enterprises implementing HACCP are presented and compared to the results of Audit 2 which was performed after the implementation of PRPs. After the implementation of HACCP a significant difference was found in all 4 parts of the audit.

Concerning part A, "building and facilities", the mean scores of Audits 2 and 3, increased from 25.00 to 26.62 (table 4.2, chapter 4). A significant difference exists between Audits 2 and 3 (p=0.001) (table 4.4, chapter 4). That was due to the fact that after audit 3, 16 of the enterprises were still in the process of changing building and facilities as the required changes were time consuming. These included 2 of the premises that had to change their working surfaces to stainless steel, the 8 premises that had to separate areas of hot and cold preparation, the 2 premises that had to add extra rest rooms, the 3 premises that had to change their floor, and the small factory that was still in the building process.

Concerning part B, "cleaning and disinfection", tests reveal significant differences between Audits 2 and 3 (table 4.7, chapter 4). The mean scores (table 4.5, chapter 4) show an increase from Audit 2 (17.84) to Audit 3 (19.10). Before HACCP implementation, none of the enterprises had a written cleaning schedule. During HACCP implementation, the HACCP team suggested a cleaning schedule based on the building and facilities of each enterprise and the frequency of the cleaning. The cleaning schedule helped personnel to clean all parts of the premises effectively, including production area, storage, fridges, rest rooms etc. An improvement was made due to the frequency of cleanliness of fridge handles and the mixer equipments. Worsfold and Griffith (2003) stated that effective cleanliness is an important control in preventing foodborne illnesses. A cleaning checklist was prepared by the HACCP team for personnel to check and sign when completing cleaning. After implementation of HACCP there was an improvement in cleaning due to the cleaning schedule and the checklist. Personnel used the cleaning schedule as a reminder for the frequency of cleaning, and the parts of the premises that had to be cleaned. At the end of the HACCP implementation, all of the premises were checking and signing every time cleaning was carried out.

Comparing cleaning before any intervention, after PRPs, and after HACCP, there was an improvement. That was due to the training of personnel, after implementation of PRPs, in cleaning and disinfection procedures including sanitation and cleaning chemicals, and due to the cleaning schedule and checklist after the implementation of HACCP. After the implementation of HACCP an improvement was also observed in sicknesses report. The HACCP team prepared a sickness report form and most of the premises kept sickness information regarding employees.

The implementation of HACCP, and all required documents and records that the enterprises had to complete, produced time problems. In the literature time is considered a major barrier in HACCP implementation (Mortimore, 2001; Walker *et al.*, 2003). Panisello and Quantick (2001) reported that the behavior of personnel towards the food management system is affected by the lack of time that is due to the need to follow the procedures.

Concerning part C, “production and process control”, the mean scores show a small increase from Audit 2 (13.06), conducted after the implementation of PRPs, to Audit 3 (13.96) conducted after the implementation of HACCP (chapter 4, table 4.8). There was a highly significant difference between Audits 2 and 3, (table 4.10, chapter 4).

During the implementation of HACCP, a HACCP plan was developed for each of the premises, according to the Codex Alimentarius guidelines (Appendix E1). The HACCP plan was based on the production and the flow diagrams of each enterprise (Appendix E2). Each HACCP plan identified the microbiological, physical and chemical food hazard, the CCP's, critical limits, monitoring, corrective actions, and documentation. Enterprises were faced, for the first time since the application of the system, with procedures like identification and control of hazards, monitoring of critical limits, corrective actions etc. At the beginning the enterprises were positive on changing and/or adding these procedures on their every day jobs.

Temperature was one of the CCPs identified in all of the enterprises. Storage temperature, fridge temperature, display units temperature, and cooking temperature, were identified as CCPs. The critical limit for fridge and cold display temperatures was that the relevant temperature was below 8˚C, for the cooking temperature above 75˚C, and for the hot holding temperature above 63˚C. Corrective actions had been suggested in case those temperatures were not the relevant ones. For fridge and cold display, personnel were advised to dispose of any food that hadn't been stored with the relevant temperatures. This is very important, especially in Cyprus, since due to the very hot weather conditions foodstuffs that are not store in the relevant temperatures are not suitable for consumption. Personnel needed to ensure that food was stored outside the danger zone of 8-63˚C.

To guarantee that the food had been stored at the correct temperatures, monitoring procedures were developed. During the implementation of HACCP, the HACCP team prepared record forms for temperature record keeping. These records were also required for principle 7 of HACCP. In order for the premises to keep these records, they needed thermometers and a person responsible for monitoring the temperatures. After implementation of PRPs all enterprises had calibrated thermometers, and after the implementation of HACCP 40 of the enterprises had a person in charge of temperature monitoring. Due to these changes there was an improvement in the results of temperature monitoring and the behaviour of the personnel in ensuring food safety. As discussed previously, an overall improvement in temperature monitoring was detected as a result of the implementation of PRPs, excluding monitoring of the cooking temperature where premises showed limited improvement. After implementation of HACCP, with the introduction of a person in charge, there was an improvement in monitoring cooking temperature.

Inspection of incoming products was another CCP identified for all enterprises. After the implementation of PRPs enterprises started inspecting incoming products as discussed in 5.2.1.1. After the implementation of HACCP all of the enterprises carried out inspections of incoming products for temperature, expiration dates, damage, and contamination, according to the critical limits presented in the HACCP plan. Any incoming product that wasn't delivered at the relevant temperature or with the appropriate expiration date was rejected and sent back to the supplier.

After the implementation of HACCP, from the 50 SMEs, 25 of the enterprises had documented a stock rotation system. The HACCP team prepared a list of suppliers with the goods supplied and the frequency that they are purchased. Enterprises had to record all non-conformity incoming products in the stock rotation system. Fifteen of the enterprises refused to complete the list of suppliers and the non-conformity products, stating that they didn't have the time to do it. The rest of the enterprises (10) stated that they purchase all products on a daily base due to the type of their job and the size of their enterprises, so they don't need a documented stock rotation system.

After the implementation of HACCP there was an improvement in the method by which food was stored in the fridge, and on the display units. After PRPs, 20 of the enterprises started to cover the stored food, but none of the enterprises was labelling this food. After the implementation of HACCP, 45 of the enterprises started to cover and label the stored food. The 5 enterprises that failed to label the stored food claimed that due to their production they don't need to store food more than a day. After the implementation of HACCP, enterprises claimed that it was difficult to label and date all stored food due to time limitations and the limited number of personnel working in the enterprises. To overcome this problem, enterprises suggested storing food in the suppliers' packages that display the expiration dates on them.

At the end of the implementation of HACCP, enterprises realised the documentation is instrumental in ensuring a due diligence defence in court. Cyprus has a legal "due diligence" defence Literature classified "due diligence" as a statutory defence available for food enterprises that commit an offence. A benefit of HACCP is to assist an enterprise in proving a due diligence defence in a court. If an enterprise can prove through a written format of records kept that all precautions were taken, and show all due diligence attempting to prevent and avoid an offence, can be found not guilty even though the offence can be proved to have occurred (Anon, 1990; Henson *et al*., 2000;

Roland, 2002). Principal 7 of HACCP requires efficient records and well documented procedures needed in ensuring due diligence defense. Documentation should be assembled in a user friendly manual that is accessible for reference (Mayes, 1999).

At the end of the implementation of HACCP all 50 enterprises had documented procedures and kept records. Among the records kept were the cleaning schedule, the cleaning checklist, the temperature record forms, the suppliers list, the non-conformity incoming product form, and the sickness report form. Comparing the results on the documentation after the implementation of PRPs and after the implementation of HACCP, an improvement was observed. After the PRPs few enterprises had documented procedures or kept any records. They stated that through HACCP they understood record keeping.

Most of the enterprises complained of difficulties in record keeping and documentation due to time limitations and the number of personnel needed to maintain the system and to keep the records. Twenty five of the enterprises stated that they needed more time to fill in all paperwork, or more staff to deal with the HACCP system and to monitor all CCPs. Tailor and Kane (2004) recognised that excess documentation and record keeping can act as a barrier to the implementation of the HACCP system. Many authors, including Mortlock *et al.* (1999), Panisello and Quantick (2001), Panisello *et al.* (1999), and Ward (2001), suggested that time constraints and the additional documentation required are the most important barriers. These barriers are not on the same magnitude to all enterprises but vary according to their size. European legislation (EC) 852/2004 provides flexibility in documentation for SMEs. As stated in recital 15 of the legislation, sufficient flexibility of HACCP requirements should be provided in all cases including small businesses. It must be recognized by government authorities that it is not possible for some food enterprises to fulfill all HACCP requirements, and some of them can be replaced by GHPs. What is more, flexibility should be provided for the retention of documentation in small businesses. This way many burdens can be avoided without compromising food safety.

Concerning part D “performed evaluations” a large increase was noted between the mean scores (table 4.11, chapter 4) of Audit 2 (2.30) and Audit 3 (4.64), as 48 of the enterprises performed the laboratory analyses after the implementation of HACCP in level 4 (table 3.1). Test reveals significant differences between Audits 2 and 3 with (table 4.13, chapter 4). At the end of the implementation of HACCP 48 of the enterprises performed the laboratory analyses on food, water, working surfaces, and personnel’s hands. These analyses were used for validation of the system, food safety, and hygiene practises. All the analyses were conducted by accredited laboratories according to the international standard ISO 17025 (ISO, 2005b). The samples were collected with the methods described in section 3.7.3, chapter 3. Most of the enterprises complained on the costs of performing these analyses as they spent large amounts of money. Many authors recognized cost as a major barrier for the implementation of HACCP (see for example Azanza and Zamora-Luna, 2005; Taylor and Kane, 2004; Walker *et al*., 2003; WHO, 1999). With the application of HACCP an enterprise could face financial barriers due to the need to engage specialized personnel, or co-operate with external consultants and laboratories.

5.2.1.3 Audit HACCP / CYS244

All 50 enterprises implemented HACCP and moved on to the implementation of CYS244 in level 6 (table 3.1). In this section the results of Audit 4 (performed after the implementation of CYS244) are presented and compared to the results of Audit 3 performed after the implementation of HACCP.

Concerning part A "building and facilities", a small increase was recorded in the mean scores between Audits 3 and 4 from 26.62 to 27.46 (table 4.2, chapter 4). This resulted from the fact that major changes took place at the beginning of the implementation of the system with only some minor improvements taking place on a later stage. A small significant difference exists between Audits 3 and 4 with p=0.039 (table 4.4). That was again due to the fact that after Audit 3 (after the implementation of HACCP) most of the enterprises had already finished with all the required changes in building and facilities. After the Audit 4 (after implementation of CYS244) only 5 of the enterprises were still in the process of making changes, including the 3 premises that had to change their floor, a premise that had to add an extra rest room, and the small factory that was still in the building process.

Concerning part B, "cleaning and disinfection", in Audit 4 there was a decrease in the mean scores from 19.10 in Audit 3 to 18.20 in Audit 4 (table 4.5, chapter 4). Comparison between the two audits (Audits 3 and 4) reveals a highly significant difference with p=0.001 (table 4.7, chapter 4). That was due to the complexity and the demands of the CYS244 and the general belief of the employees in excessive requirements. Twenty five of the enterprises terminated various bureaucratic procedures, like the cleaning documentation and cleaning record keeping. Motarjemi and Kaferstein (1999) expressed negative views on extensive documentation.

After implementation of CYS244 in level 6 (table 3.1), cleaning and disinfection procedures became more complicated. Enterprises started the cleaning procedures by cleaning and sanitizing surfaces and equipment. A thorough wash of all surfaces was essential to achieve the best results from the subsequent disinfection. Personnel had to wash all surfaces with a pressure washer using a detergent sanitizer solution. They had to clean all equipment and furnishings, including any removed from the premises, ensuring that they were all visibly clean.

After a cleaning procedure the level of disease organisms present may still be high enough to cause serious health hazards. Thus, disinfection was essential after the cleaning procedure. After the implementation of CYS244 in level 6 (table 3.1), premises were using effective disinfectants against viruses, bacteria, yeasts, and moulds. Personnel disinfected all removable equipment and replaced. Then they disinfected the cleaned premise by applying disinfectant solution evenly to all washed surfaces. During disinfection employees paid particular attention to corners, cracks, and porous surfaces. To avoid introduction of an infection, all personnel were using foot dips on entering the production area. In addition, only authorized personnel were allowed to enter the production area. Visitors, including engineers, cleaning teams, etc. were provided with full protective clothing as they are frequently the cause of spread of infections. Concerning waste disposal, empty detergent and disinfectant containers were disposed of as standard waste after a thorough wash and any partfilled containers or other special products were disposed of as hazardous waste. Cleanliness of the premises was maintained at all times.

At the end of each day managers checked and signed that the final cleaning was carried out. In order to check the effectiveness of the cleaning an extra form was added to be signed by the manager. In case a problem was identified regarding cleaning and/or disinfection, corrective actions were taken and personnel had to report all the corrective actions on a new form. Enterprises faced difficulties in keeping this extensive documentation such as cleaning checklist, cleaning schedule, corrective action form, and manager's checklist form.

Comparing cleaning before and after implementation of CYS244 there is a decrease on the improvement of cleaning (table 4.5). That was due to the complicated cleaning procedures and the extensive documentation. Twenty five of the enterprises stopped cleaning according to the sanitized procedures and returned back to their old habits. They also stopped completing all the extra documentation, the management approvement form, and the corrective action form. Ten of them stated orally that they forgot to complete all the documents every day.

Concerning part C "production and process control" the mean scores increased from 13.96 in Audit 3 to 15.36 in Audit 4 (table 4.8, chapter 4). A comparison between the two audits (Audit 3 and Audit 4) reveals a highly significant difference (table 4.10, chapter 4).

After implementation of CYS244, the management had the obligation of ensuring a food safety policy according to the goals of the enterprise, the clients' requirements, and the legislation. Through the food safety policy, enterprises had the obligation to provide the necessary resources in producing safe food and were committed to the principles of HACCP. All employees were expected to behave in accordance with the safe food policy and enterprises agreed to provide employees with all essential facilities and training. The responsibilities of managers and employees were detailed under job description records. Responsibilities were also listed under the organization structure. According to CYS244, the management should appoint a person as a HACCP coordinator. The HACCP coordinator was responsible for ensuring implementation, operation, and maintenance of HACCP system. He/She was responsible to report to the management regarding effectiveness, adequacy, and improvement requirements of the HACCP system, and was also responsible for organizing the tasks of the HACCP team. The HACCP team members were in a constant communication throughout the working days.

All documented procedures and records were monitored and reviewed frequently. The documentation of HACCP system was under the direct control of the HACCP coordinators. HACCP system records, as an evidence of control, must be kept for a minimum of two years as a result of legal requirements. In accordance with national standard CYS244, files for training, review, HACCP evaluation, CCP monitoring, corrective actions, validation, raw material, product cleaning and disinfection, pest control, calibration, laboratory analyses, and traceability, were opened and maintained. All non-conformity products were recorded on a daily inspection record.

A list of monitoring equipment calibration and respective calibration certificates was recorded.

After the implementation of CYS244, 19 of the enterprises had complete documented procedures. All of the enterprises complained orally to the researcher about time constraints and the level of knowledge required in order to maintain the system and to keep the records. After the implementation of CYS244 the HACCP plan was more descriptive as it combined food safety and management issues and became more difficult for personnel to understand.

Concerning part D, “performed evaluations”, there was a small increase in the mean score between Audits 3 and 4 from 4.64 to 4.92 (table 4.11, chapter 4). That was due to the fact that 14 of the enterprises increased the frequency of the laboratory analyses after the implementation of CYS 244. Test reveals significant differences between Audits 3 and 4 (table 4.13, chapter 4). After the implementation of CYS244 all enterprises performed at least one water analysis. Laboratories conducting the analyses explained to the enterprises that all water systems contain some bacterial contamination, especially heater tanks where dust and debris can accumulate. That could be a source of disease. Sanitizing would clean the system and eliminate unwanted bacterial or fungal growth. Drinking water could be a potential source and spread of infections. Header tanks and pipelines needed to be regularly cleaned and disinfected. Enterprises claimed that the only source of infection in their premises could be birds. In Cyprus, due to the Mediterranean weather, many enterprises had problems with birds that were infected with viruses and other diseases and could contaminate drinking water.

Concerning part E, “HACCP system documentation” mean scores between Audits 3 and 4 show an increase from 84.66 to 88.14 (table 4.15, chapter 4). That was due to the fact that the enterprises were keeping all the records required by the HACCP system. Table 4.17 shows a highly significant difference between Audits 3 and 4. After the implementation of CYS244, during Audit 4 performed in level 6 (table 3.1), most of the enterprises had already got documented procedures in place. Enterprises complained about the bureaucratic form of the system, the high costs, and the time they had to spend on documentation and record keeping.

After the implementation of CYS244 21 of the enterprises had a food safely policy, documented procedures, documentation with operation instructions, and verified specifications. Documented procedures included detection and testing procedures of the non-conformity products, procedures for notification/trace of a product, cleaning procedures, pest control, training, and calibration.

For traceability enterprises had a list of authorities in charge and clients that had to be notified, a mechanism for collecting traced quantities, and ways of calculating any remaining quantities. Regarding pest control procedures after the implementation of CYS244 (level 6, table 3.1), all of the enterprises had confirmation systems for the effectiveness of the pest control measures in effect, and corrective actions. For the training procedures, 21 of the enterprises had evidence of training of the personnel, and a plan for ascertaining the training needs. Concerning calibration procedures, all of the enterprises had their equipment tested and calibrated.

5.2.1.4 Audit CYS244 / ISO22000

This section presents the audit results of the enterprises that implemented CYS244 and moved on to the implementation of ISO22000 in level 8 (table 3.1). All 50 enterprises moved on into the implementation of ISO22000.

Concerning part A "building and facilities", no change in the mean score (27.46) was found in the last two audits (Audit 4 and 5) since no further changes were performed in building and facilities (table 4.2, chapter 4). No significant difference was recorded since there were no changes in the building and facilities. At the end of level 6 all enterprises completed all the changes needed concerning building and facilities. The 2 enterprises that needed to put in a new floor completed the change and put in a poured resin one with wall to floor junctions rounded. All enterprises had non slip, waterproof flooring which was easy to clean and disinfect. Hand wash basins were separated from equipment wash basins and were appropriately marked. Also all instruments and working equipment, including cutting tables and containers, were made of corrosion resistant materials that were easy to clean and disinfect.

Concerning part B "cleaning and disinfection", there was a decrease in the mean score from 18.20 in Audit 4 to 16.46 in Audit 5 (table 4.5, chapter 4). A comparison between the two audits (audits 4 and 5) reveals a highly significant difference (table 4.7, chapter 4). The decrease in the mean score was due to the complexity of the cleaning and disinfection procedures, and due to the fact that the enterprises were tolerant to the changes for a long time. The personnel developed a negative attitude towards the system, they fed up all these changes, and there was a lack of motivation. This resulted in the termination of the complicated and bureaucratic procedures by 29 of the SMEs. During implementation of ISO22000, 29 out of the 50 enterprises stopped the cleaning procedures that they applied through the management systems. Personnel mentioned that they were still cleaning their premises but in the same way they did before the implementation of the food management systems.

Concerning part C "production and process control", there was a decrease in the mean score between Audits 4 and 5 from 15.36 to 12.90 (table 4.8, chapter 4) since by the end of the application of the system enterprises felt, as mentioned to the researcher, that the system was too much for them. To this end, 39 of the enterprises decided to stop those procedures that felt they were holding them back from carrying out their everyday work. The terminated procedures included procedures of record keeping and documentation of the system. In particular, they stopped completing all the documents concerning the procedures of control and maintenance, the files concerning pest control, calibration, traceability, training, cleaning review and validation. Eleven of the enterprises were still keeping documents concerning the procedures of hazards control and CCP monitoring such as temperature monitoring records, non-conformity products report, and the corrective actions.

Concerning part D, "performed evaluations", the mean score (4.92) of the last two audits, Audits 4 and 5 (table 4.11, chapter 4) is the same. There is no significant difference (p=1.000) between these two audits (table 4.13, chapter 4) since none of the enterprises underwent any changes concerning the performed laboratory analyses. Even though the enterprises performed only the necessary analyses, required by the legislation, all of them were complaining of the increased costs of these analyses.

Concerning part E “HACCP system documentation”, the mean score for Audit 5 decreased from 88.14 in Audit 4 to 62.04 (table 4.15, chapter 4). This shows that the enterprises could not apply a more complicated form of the system. Many of the enterprises decided that they could not continue with the application of the system, and terminated most of the procedures that they had already applied. At the end, 48 of the enterprises had a copy of the system’s manual but most of them were not using it. Visual images of personal hygiene and cross-contamination were displayed in all enterprises. Even though enterprises had all required information in their HACCP manual, an active workable system did not exist due to the complexity and the bureaucratic form that the system developed at the end.

5.2.1.5 Audit before intervention / ISO22000

This section presents the audit results of the group of premises that completed the project and implemented the food management systems (PRPs, HACCP, CYS244, and ISO22000).

Concerning part A, “building and facilities”, enterprises completed all building and facilities changes that needed to be done. At the end of ISO 22000 all 50 enterprises had better building facilities than before any intervention. Even though most of the enterprises terminated the application of the system, there was an improvement in the building and facilities. Table 4.2 shows an increase in the mean score after completion of the system (27.46) compared to the mean score before any intervention (10.82). What was left from the system were the changes to the building and facilities. These changes were important for food safety since, as discussed later in the chapter, there was a decrease in cross contamination.

Concerning part B, “cleaning and disinfection”, an overall slight improvement was observed after completion of the research. Table 4.7 shows a highly significant difference between Audits 1 and 5. Mean scores show an increase from Audit 1 (12.04) before any intervention, to Audit 5 (16.46) after the full implementation of the food management system ISO22000 (table 4.5, chapter 4). That was due to the knowledge on cleaning and disinfection that the personnel gained from the training, and the professional cleaning chemicals used by the personnel. At the end of the research most of the enterprises stopped the complicated ways of cleaning required by the system (as described in 5.2.1.4) and stopped keeping the cleaning documentations and records. Personnel reported that complicated cleaning procedures and cleaning documentation were difficult to follow during the preparation of their products. Time was limited for these kind of enterprises (SMEs) due to the small number of employees. In general, the mean score of Audit 5 is higher than the mean score of Audit 1 since enterprises were still using some of the knowledge gained through the implementation of the system. Even though the final mean score in Audit 5 is higher than the mean score before any intervention in Audit 1, it isn’t as high as was expect after the implementation of PRPs (Audit 2). After the implementation of PRPs a major improvement was observed in cleaning and disinfection. That was due to the personnel's understanding of the correct ways of cleaning and the extra effort made in cleaning. They also started using the appropriate sanitation chemicals for cleaning. Most of the enterprises stated that due to the change on the chemicals used, cleaning became easier. When cleaning procedures became more complicated and documentation and record keeping were required (after the implementation of CYS244 and ISO22000) most of the enterprises stopped the cleaning documentation and record keeping and returned to their old way of cleaning. The best results were observed after the implementation of PRPs and during the implementation of HACCP (table 4.5). The decrease in the mean scores after the implementation of CYS244 and ISO22000 suggest that these systems were inappropriate for these kind of enterprises (SMEs). The reason that SMEs made the effort to apply these systems was to get the HACCP certificate and the only way to achieve this was by applying a food management system based on a standard (CYS244 / ISO 22000) as there is not any certificate based on legislation. Simplified cleaning procedures and schedules would be more appropriate for an SME. These procedures are included in Safer Food - Better Business (FSA, 2005) and in the national guides provided by the government (Ministry of Health, Cyprus, 2004). Based on these simplified ways of cleaning, the improvement seen from Audit 1 to Audit 2 after the application of PRPs could have been achieved and maintained.

Concerning part C, "production and process control", tests reveal significant differences between Audits 1 and 5 (p=0.004, table 4.10, chapter 4). The overall results show an improvement in the mean scores of Audits 1 and 5 from 11.64 to 12.90 (table 4.8, chapter 4). After HACCP implementation and guidance, personnel were aware of CCPs, critical limits, monitoring, and corrective actions. Also, practices such as temperature monitoring, inspection of incoming products, and stock rotation system, were found to be followed by most of the enterprises. Even though they stopped the extensive documentation and record keeping concerning pest control, calibration, traceability etc., they continued to perform the controls and the maintenance of the CCPs. The extensive documentation on management issues like customer complains, management reviews, traceability etc. were not important for the food safety as these procedures were not connected directly to food safety. Record keeping does not directly affect food safety, rather it is mostly used in proving a due diligence defense in court. Enterprises continued record keeping on temperature monitoring, on the inspection of incoming goods, and corrective actions. These documents are considered important for food safety.

A reason that forced the enterprises to stop the extensive documentation was the time limitations, the small number of employees, and the perception that the recommendations on similar issues differed from one government auditor to the other, an inconsistency that complicated further the application of the system. As stated by the enterprises, due to these different recommendations, they had to make changes in the system every time a government auditor performed an inspection.

The analyses performed in all parts of the five audits, conducted over the different levels 1, 2, 4, 6 and 8 (table 3.1), show that at the beginning enterprises had a positive intention of implementing the HACCP system, and great effort was made in applying it. They thought the system was helpful and could prevent any foodborne outbreaks. There was a positive attitude towards changes required for implementing the HACCP system. Over the different levels of implementation, the system became more complicated and both the requirements and the bureaucracy increased. As a result the enterprises became negative in implementing the system. All of the enterprises complained about the complicated procedures of the documentation and record keeping. In most of the cases, due to a very busy day, documents were not completed. Personnel stated that their job was to cook, serve, and clean and not to fill documents. As a result, most of the enterprises terminated completely the application of the system. From the results of the study it appears that an enterprise can apply the system up to a specific complexity limit. Exceeding this complexity limit of the system resulted in negative results (e.g. terminations of the application of the system).

To conclude, for the food safety target of the HACCP system to be accomplished, flexibility must exist. Every enterprise has its own application limit regarding the complexity of the system. When this limit is exceeded negative results appear for the enterprise and for food safety in general. For a proper functioning of the system, government auditors and certification bodies must take into consideration these limits for each enterprise, and adjust the system and their demands. Important documentation for food safety included monitoring of CCPs like temperature monitoring, incoming products inspection, cleaning, monitoring of critical limits, and corrective actions.

5.2.2 Attitude

This section analyses the results regarding personnel's attitude towards HACCP obtained through a questionnaire. Attitude problems were found to act as barriers for HACCP implementation among the industry (Panisello and Quantick, 2001). The questionnaire was applied to all enterprises through four evaluations in different levels, after PRPs, after HACCP, after CYS 244, and after the implementation of ISO22000 (table 3.1). The questionnaire was used in order to assess the attitude of personnel. At the beginning of the research enterprises had been motivated in applying the food management systems due to the low staff turnover, the HACCP certificate, and the intention for making an investment in their enterprise. These motivations led the enterprises to develop a positive attitude towards the food management systems. Gilling *et al.* (2001) reported that attitude is affected by knowledge, motivation and intention. Henson *et al.* (2000) and Panisello and Quantick (2001) stress the importance of motivation of staff in maintaining an effective HACCP system.

The aim of assessing attitude was to measure food handlers'/managers' attitude towards HACCP over the various coaching sessions provided through the study, and to observe any changes in attitude. As a tool for this assessment a questionnaire was used. As discussed in the Methodology chapter, at the time the questionnaire was designed, no published questionnaire was available for assessing attitude towards HACCP. The design of the questionnaire, as discussed in 3.7.2, was based on a review of current literature, to better understand current topics related to attitudes and beliefs, and to the experts' opinion. While a great effort was made to ensure that the questionnaire encompass all major areas required, a possibility exists that some important points were overlooked, including any psychological determinants of relevant behaviors in the food industry. However, as discussed in 3.7.2.2, the experts' panel indicated that the answers to the individual questions gave a good insight level to the opinions of the enterprises. At the end of the study, SMEs developed a negative attitude towards the food management systems due to the different barriers that they faced during the implementation of the food management systems.

In what follows, the results of the managers' attitude are presented. As shown in table 4.19 (chapter 4) significant differences exist between consecutive questions of the questionnaires. Table 4.18 summarises the total mean scores of each question achieved by the 50 enterprises over the four evaluations of the questionnaire in the four different levels 2, 4, 6, 8 in which the questionnaire was performed (table 3.1).

5.2.2.1 Questionnaire PRPs / HACCP

In what follows, the results obtained from the evaluation of the questionnaire after the implementation of PRPs will be presented and compared to the results of the questionnaire after the implementation of HACCP. The total score of 2182 (Appendix D2) indicates the summed score of the 50 enterprises after the implementation of PRPs (level 2, table 3.1). The total score of the second evaluation of the questionnaire (2375), performed after the implementation of HACCP, showed an increase compared to the score of the first evaluation of the questionnaire. That was due to the positive attitude of the personnel towards the system. Personnel found the system helpful and believed that the system could protect them against customer complaints and prevent offence through due diligence.

Each question was analysed separately over the different evaluations of the questionnaire and the results are shown in table 4.18. In question 1, respondents were asked on how flexible they think the system is. The overall results showed that even after PRPs the total mean score was 4.08 (table 4.18), so that personnel appeared to have a positive attitude towards flexibility of the system. The decrease in the total mean score (3.56, table 4.18), after the second evaluation (after the implementation of HACCP), reflects the negative attitude concerning flexibility after HACCP. There is a significant difference (table 4.19, chapter 4) in the managers' attitude between the implementation of PRPs and HACCP. That indicates that the intervention altered the attitude of managers as it was based on the HACCP system.

Regarding question 2 there was a decrease in the total mean score from 4.20 to 3.66 (table 4.18) from the first evaluation of the questionnaire to the second evaluation after HACCP. A significant difference between the two evaluations could be measured (table 4.19, chapter 4). After the implementation of HACCP respondents agreed that HACCP system could not be easily implemented in SMEs. This change in attitude was expected as managers had no motivation to follow the system's requirements. Literature suggests attitude is influenced by industry's intrinsic factors. These factors which are based on human response could be outcome expectancy, self-efficacy and motivation (Azanza and Zamora-Luna, 2005, and Gilling *et al*., 2001).

Analysing table 4.18 it was found that after the implementation of HACCP most of the respondents found the system bureaucratic, difficult to keep records, complicated and costly. That attitude was reflected through questions 3 to 6. For these questions reverse-phrasing was applied and the ranking was reversed before analyzing them. These results indicated that the knowledge obtained by the PRPs training and HACCP on food safety practices was beneficial for the personnel but they still had difficulties to implement HACCP system. The personnel believed that the training and coaching on food safety helped them to better understand the food safety issues but it was still difficult for them to keep the system's records. The main objective of the training on PRPs and coaching on HACCP was to provide knowledge, awareness, and understanding in PRPs and the HACCP principles. Personnel stated that they were more aware of food safety issues but that didn't helped them to develop a positive attitude towards the food management systems.

Results for questions 7 and 8 on the usefulness of the system show no change in the total mean scores (3.57, table 4.18). A small decrease in the total mean scores from 3.44 to 3.22 for customer complaint was observed in question 8. That decrease suggested less acceptance to food safety and HACCP. Most of the managers believed that the HACCP system could prevent any customers' complaints. They mentioned that they didn't want to have a bad reputation among their customers.

Concerning the managers' perception on the improvement of their products, table 4.18 shows an increase in the total mean scores from 2.43 to 2.52 after the implementation of HACCP. Concerning managers' perception on the swab test results and the audit results, they didn't think that there was an improvement. Managers believed that the HACCP system helped them in their every day work due to the cleaning schedule and monitoring procedures. Managers stated that they had a better control of their every day work and so there was an increase in the mean scores of question 12 fro 3.24 to 4.04. Tests for significant differences between the same questions over consecutive evaluations of questionnaire show high significant differences for the majority of the questions validating the above points (table 4.19).

Concerning the degree the system helped personnel to improve their knowledge, all respondents strongly agreed that training on PRPs and coaching on HACCP was an important part of the implementation of the system, and helped them improve their knowledge. The results from table 4.18 indicate that the acquired knowledge was beneficial for personnel. If personnel don't have the knowledge and motivation to follow the system's requirements, they would experience negative attitudes.

Figure 4.11 indicates that after PRPs, 5 of the enterprises wanted to terminate the implementation of the system. In the second evaluation, after HACCP implementation, 3 more enterprises stated that they wanted to terminate the system, giving a total of 8 enterprises. Managers claimed time limitations, the small number of employees, and the costs, as the main barriers for implementing the system. Additionally, it was found that these managers believed that HACCP would have a large impact on the daily run of their business. Managers were not convinced of the importance of the system. Literature suggest that if managers are not convinced of the importance of the system, then enterprises can not provide the adequate resources and the required motivation to their employees (Panisello and Quantic, 2001; Strohbehn *et al.*, 2004). The 8 managers that stated, after the implementation of HACCP, that they wanted to terminate the system, believed that HACCP would be complicated for their employees, something that was also noticed in the literature (Eves and Devrisi, 2005). Taylor and Kane (2004) found that one of the barriers that delays HACCP implementation is the lack of managers' skills.

5.2.2.2 Questionnaire HACCP / CYS244

In this section the results obtained from the third evaluation of the questionnaire after the implementation of CYS244 are presented and compared to the results of the second evaluation of the questionnaire after HACCP implementation. The total score of the third evaluation of the questionnaire (2148) decreased compared to the total score of the first evaluations (2182) and second evaluation (2375) (Appendix D2). The third evaluation of the questionnaire was performed after the implementation of CYS244 where the enterprises started implementing a more complicated form of the system. Their attitude towards the system started to be negative. At the beginning, most of the enterprises regarded the system as beneficial. Personnel were pleased to work in a clean environment (cleaning, changes in infrastructure, new equipment) and valued the fact that the system helped them to establish good working conditions. At the end the use of complicated manuals and documentation procedures was a major drawback for the enterprises.

Concerning question 1, on personnel's opinion on the flexibility of the system, there was a reduction in the mean score reflecting the increase in the complexity of the system. Personnel appeared to develop a negative attitude towards the flexibility of the system after the implementation of CYS244. There is a significant change in managers' attitude on the flexibility of the system after the implementation of CYS244 (table 4.19, chapter 4).

Respondents believed that CYS244 could not be easily implemented in SMEs. The mean score (1.88) (table 4.18) for question 2 shows a decrease after implementation of CYS244 compared to the mean score (3.66) after the implementation of HACCP. Managers developed a negative attitude as they considered the system to be complicated and beyond the capabilities of their employees. Literature suggests that attitude problems are one of the barriers for the implementation of the food management systems. Henson *et al.*, (2000) stated that employees are an important element in maintaining on effective food management systems.

Comparing the mean scores (table 4.18) of questions 3 to 6, after the implementation of CYS244, to the mean scores after the implementation of HACCP, it is clear that respondents found the system bureaucratic, difficult to keep records, complicated, and costly. Managers claimed that they could not understand the requirements of CYS244, and that it was complicated and confusing for personnel to implement it. The reduction in the mean scores of questions 7 and 8 (table 4.18) clearly indicate the negative opinion of the personnel on the usefulness of the HACCP system and in the reduction of the customers' complaints. Managers felt that the system wasn't as useful as before due to the difficulty to understand and implement it.

Concerning questions 9-12 there is a sharp decrease in the mean scores (table 4.18) based on the managers perception on the improvement of their products, swab tests, audit results, and their every day work. They developed a negative attitude as they believed that the system could not help them to improve any of the above due to its complexity and the difficulties in its implementation. The decrease in the mean score of question 13 from 4.42 to 3.84 (table 4.18) suggests a negative attitude on their perception of the improvement of their knowledge. Intervention of the implementation of CYS244 negative altered the attitude of personnel. The implementation of CYS244 was through training and it was a knowledge based intervention.

Figure 4.11 indicates that after the implementation of CYS244 the number of enterprises wanting to terminate the system increased to 29. Managers claimed that the system, based on CYS244, was very complicated and they could not fulfill its requirements. Managers had no motivation to implement such a complicated system as they believed that they were already producing safe food based on the implementation of PRPs and HACCP principles. Similar findings were reported by Taylor (2001) who suggested that in SMEs managers had no motivation to implement food management systems.

5.2.2.3 Questionnaire CYS244 / ISO22000

In what follows, the results obtained from the fourth evaluation of the questionnaire after the implementation of ISO2000 are presented and compared to the results of the third evaluation of the questionnaire after CYS244.

The total score of the fourth evaluation of the questionnaire (1977) (Appendix D2) decreased even more compared to the total score of the third evaluation of the questionnaire (2148). This was due to a further negative attitude of the personnel towards the system. When a more complicated form of the system was implemented enterprises came across several different barriers including time-related constraints and a large amount of documentation was required. The complicated form of the system that enterprises had to implement did not comply with the fast moving environment of the food industry. It was evident that personnel were interested in their everyday job and the survival of their companies, as most of them were family companies, and not in the implementation of a bureaucratic and high cost system. The decrease in the mean scores for question 1 from 2.08 to 1.58 (table 4.18) indicates that personnel believed that the system, after the implementation of ISO22000, wasn't flexible. A significant difference exists (p=0.000) in the mean scores between the same question over the four evaluations (table 4.19, chapter 4). That indicates that the requirements of ISO2000 exceeded the limitations of the enterprises. Also, enterprises claimed that it was very difficult to implement ISO2000 in an SME. The mean score for question 2 (1.26) (table 4.18) show a decrease compared to the mean scores after the implementation of CYS244. That was due to the negative attitude of personnel toward the system.

Comparing the mean scores of questions 3 to 6 (4.18), after the implementation of ISO22000, to the mean scores after the implementation of CYS244, managers found the system bureaucratic, difficult to keep records, complicated, and very costly. Negative views on extensive documentation involving the system had been expressed by all the enterprises. At the end, all enterprises returned to their normal working habits. After all this effort only the infrastructure changes remained according to the system's requirements as most of the enterprises stopped the application of the food management systems. Managers believed that the system wasn't helpful and it was completely unnecessary for the size of their enterprises. That is clear from the mean scores 1.64 and 1.90 of questions 7 and 8 respectively (table 4.18), after the implementation of ISO22000, compared to the mean score of 2.18 and 2.50 after the implementation of CYS244. Similar decrease in the mean scores can be noted (table 4.18) concerning questions 9-12. Managers stated that there was no improvement on their products, on the swab tests, the audit results, and their everyday work. Thus, they claimed that the system was a barrier for their everyday work. That negative attitude led personnel to terminate most of the procedures based on the system's requirements.

Concerning knowledge, the decrease in the mean score form 4.22 to 3.84 (table 4.18) indicates that personnel believed that the implementation of ISO22000 didn't help them improving their knowledge. What is more, the complicated terms and requirements confused them even more. Personnel believed that the implementation of ISO22000 was unnecessary, and didn't agree that the application of such a complicated system could prevent foodborne illnesses. Literature suggests that negative attitude acts as a barrier on the application and maintenance of food management systems. Panisello & Quantick (2001) suggest that such attitudes slow down the development and maintenance of food management systems.

Figure 4.11 indicates that after implementation of ISO22000, 45 of the enterprises wanted to terminate the system. One of the enterprises closed down at the end of the research after the implementation of ISO22000, as they could not cope with the cost. After all these effort only infrastructure changes and some hygiene practices remained according to the food management system’s requirements.

The attitude of the personnel was positive at the beginning and then negative. The reason for these was that over the different levels of implementation the complexity of the system increased in order to fulfil the requirements needed from the food management systems (HACCP, CYS244, ISO22000).

5.2.3 Environmental, Food and Water Samples

According to Kusumaningrum *et al.* (2003), potential microbial cross contamination by contact based on the detachment of surface-bound microorganisms, can be measured by microbial swab tests. Gorman *et al.* (2002) stated that pathogenic bacteria can be introduced through cross contamination of foodstuffs, people, and surfaces. Most of these bacteria can be killed during cooking, adequate hand wash, or with adequate cleaning and disinfection. Adequate cleaning is essential as bacteria, if not removed properly, can attach in surfaces and form a biofilm, a network of bacteria that under specific conditions such as warm temperature can cross contaminate food (Bower *et al.*, 1996). Den Aantrekker *et al.* (2003) stated that biofilms are extremely resistant to cleaning and disinfection and are very difficult to remove.

As mentioned in chapter 3, to examine food safety, food samples were taken from incoming goods and from the products of each enterprise. To examine the cleaning and disinfection, sample swabs from working surfaces in the premises were taken and analyzed. A sample from a clean stainless steel surface was chosen to measure the level of cleanness and sanitation on food contact surfaces. The surface sample was collected from the production area which was the high-risk area with the highest possibility of cross contamination. To examine the hygiene of the personnel, samples were taken from hands and were analysed by qualified scientists from accredited laboratories. Scientists collected microbial hand swab samples from one worker from each enterprise. The worker chosen was the person in charge for food preparation. An employee’s hand can give a good indication of their personal hygiene as well as the resulting cross contamination onto ready to eat food.

Samples varied between different days and different foods. This is entirely normal as the level of contamination varies throughout the different stages of food preparation on different days and the different products. For example, premises dealing with raw meat or salads are expected to have higher levels of contamination than premises dealing with flour and sugar. The variation in the level of contamination between premises and samples and throughout preparation period may constitute a limitation for a study that considers various premises. Samples also varied according to the time of the day that were collected. If surfaces had been recently cleaned the level of contamination would be lower. Swab test samples were varied as the frequency and time of cleaning varied between the different premises. Similarly hand swab samples varied according to the time of hand washing. If the personnel's hands had been recently washed, the levels of contamination would be low. A main limitation of swab testing is that since pathogen contamination occurs at irregular intervals and frequency a negative sample may not mean an absence of the pathogen in the premises but only that it wasn't present on that particular sample.

The most common microorganisms used in the industry as indicators of general lack of hygiene in food processing include total counts, coliforms, and enterobacteriaceae (Engel, 1998; Friedhoff *et al.,* 2005; Gillespie *et.al.,* 2000). Enterobacteriaceae tests can detect a broad spectrum of organisms (Adam and Moss, 2000). These microorganisms are appropriate to monitor the level of contamination (FSIS, 2006). For both hands and surface samples, the TVC was examined as an indicator of contamination. TVC measures the total number of culturable bacteria (per volume or area) in a given sample. Any pathogen analyses were excluded as this it would increase the cost for the enterprises. Lack of informative indicators in the analysis including coliforms and enterobacteriaceae constitutes a limitation of the environmental sampling of the study. In the swab tests for both the hands of the employees and the surfaces in the establishments, the results were originally returned in colony-forming-units (cfu/cm^2). Since measurements take extreme values, microbial counts were analysed using $\log_{10}$ transformation to improve the interpretability. The laboratories that conducted the analyses used the commission's regulation (EC) No. 1441/2007 "microbiological criteria for food stuff", and the "guide of microbiological acceptable limits for food" of the General State Laboratory in Cyprus as a reference for the acceptable microbiological limits for foodstuffs (Appendix B5). As discussed in chapter 3, there is no regulation regarding the acceptable levels of bacteria on surfaces and hands. However, based on FSA (2002) guidelines on the implementation of microbial testing procedures in meat premises, surfaces are considered satisfactory when TVC is <10 cfu/cm^2. Griffith *et al*. (2003) presented criteria used by the US Department of Agriculture and the Swedish Standards Agency that specifies microbial counts of <5 cfu/cm^2 for the cleaned surfaces and equipment for food processing plants. Literature reported microbial counts on cleaned food surfaces <2.5 cfu/cm^2 as the most common criteria of UK studies (Malik *el al*., 2003; Griffith *et al*., 2003; Cooper *et al*., 2007). Kennedy *et al.* (2007) estimated swab samples from refrigerator sides with TVCs ranging from 2.91 $\log_{10}$ cfu/cm^2 to 8.78 $\log_{10}$ cfu/cm^2. The microbiological results obtained from the hand and surface swabs analyses were high. The reason for this is that the samples, obtained by the scientists from the laboratories, were not taken straight after the cleaning of the surfaces and hand washing but after based on the scientists' schedule.

The following subsections present and analyze the results from the food, surfaces, hands, and water analyses. The analyses were performed in all 50 enterprises throughout the implementation of the food management systems in the different levels, before any intervention (level 1), after PRPs (level 2), after HACCP (level 4), after CYS 244 (level 6), and after ISO22000 (level 8) as shown in table 3.1. These analyses were performed to assess the personal hygiene of the personnel, the cleaning and disinfection, and the food safety.

5.2.3.1 Analyses before any intervention / PRPs

Results presented in chapter 4, table 4.20, suggest that there is a drop in the average mean scores from the 1st hand swab test (3.22 $\log_{10}$ cfu/cm²), performed before any intervention, to the second (2.94 $\log_{10}$ cfu/cm²) performed after PRPs. That was due to the implementation of PRPs, and to personnel training. The training included a session on personal hygiene, in which the correct ways for hand washing, the use of the materials for cleaning hands, and hygienic drying, were explained. In addition, the building and facilities changes helped personnel to improve their personal hygiene as more extra washing facilities were added. The mean score of the level of contamination for the hand swab tests obtained before any intervention appears to be the highest through all of the five hand swab tests analyses. Personnel’s hands represent a hazard as bacteria could spread and cross contaminate food. A high level of bacteria on personnel’s hands is a high risk due to the contact with food, especially the ready to eat food.

Table 4.25 shows a drop in the level of contamination from the 1st surface swab test (3.21 $\log_{10}$ cfu/cm²) to the 2nd test (2.78 $\log_{10}$ cfu/cm²). The 1st swab test was performed before any intervention and the level of contamination on the surfaces was higher than the level in the 2nd swab test performed after the training and the implementation of the PRPs. During the training personnel were trained in the correct ways of cleaning and disinfecting the facilities and the equipment. They were also trained on how to use the cleaning materials and the disinfectants. Forty seven of them didn’t use any advanced cleanings or disinfectants before the implementation of the system. The mean score for the surfaces swab tests before any intervention appears to show the highest level of contamination through all of the five surface analyses.

Each food evaluation included five high risk food samples according to the enterprises' products. The more sensitive ingredients included in a food, the higher the risk. From figure 4.16 the percentage number of violations in the 1st food analysis, performed before any intervention in level 1 (table 3.1), was 8.4%. For food samples both indicators and pathogens were tested depending on the food category. The relevant pathogens and indicators that had to be tested for each food category are provided in the guide of "Microbiological Criteria for Food" of the general chemical state laboratory in Cyprus (General chemical state laboratory, 2001) (Appendix B5) and the Commission regulation (EC) No 1441/2007 on microbiological criteria for foodstuffs. A violation was reported when the level of pathogens or indicators exited the acceptable limits. The acceptable limits are also included in the guide. A sample of the food analyses results is presented in Appendix B3. One of the violations concerned the chef's salad in a tavern which included mayonnaise, ham, cheese and vegetables. A high level of Staphylococcous aureus (1000 cfu/g) was detected. The contamination of the salad could have been due to transfer from hand during the preparation, or inappropriate temperature during the preparation or the display of the product. The food analyses were performed before any intervention during which personnel had had no training in personal hygiene. In one of the bakeries E. coli were detected (40 cfu/g) in a pastry containing mince meat. That was probably due to an inappropriate cleaning of the equipment that was used for the preparation of the product, or due to an inappropriate temperature in the production area or hot holding temperatures. Personnel had not yet been trained on the cleaning procedures through the PRPs.

In the 2nd food analysis, performed in level 2 after the implementation of PRPs, the percentage of total violations decreased to 6%. The reason for this was the implementation of the system. Personnel had been trained on personal hygiene, cleaning procedures, and temperature monitoring. That helped them to understand better the food safety issues and to develop a positive attitude towards the system. This positive attitude that the personnel showed towards the system played a significant role in the decrease of the violations in the food analyses. Incoming products also played a significant role in the observed violations. One of the fast foods had a problem with the Hallumi cheese as Staphylococcous aureus was detected (40 cfu/g). Enterprises didn’t implement the inspection of the incoming products as they didn’t have yet any procedures in place.

Concerning microbiological and chemical water analyses, figures 4.17 and 4.18 present the violations, as a percentage of the total violations. The results over the five water analyses show no significant variation. That was due to the fact that all enterprises were using the water provided by the government. For the quality of the water and the acceptable limits of the different microorganisms the general chemical state laboratory in Cyprus was responsible. In the first water analysis, performed before any intervention, results show 17 violations (3.4%, figure 4.17). That was probably due to the lack of cleaning and disinfection of the header tanks and the pipelines. All water systems contain some bacterial contamination, especially header tanks where dust and debris can accumulate. Before the implementation of PRPs when enterprises didn't have any pest control in place, one enterprise had a problem with birds contaminating the water. After PRPs the violations dropped to 12 (2.3%, figure 4.17), as enterprises applied pest control procedures and cleaning and disinfection procedures for the header tanks and pipelines. Sanitizing could clean the water system and eliminate unwanted bacterial or fungal growth.

5.2.3.2 Analyses PRPs / HACCP

In this subsection results of the analyses after the implementation of HACCP are presented and are compared to the results of the analyses after the implementation of PRPs. Also, the effect of hands and surfaces in microbial contamination as well as the safety of food and water after the implementation of HACCP are discussed.

In the 3rd hand swab test, performed in level 4 after the implementation of HACCP (table 3.1), there was a further drop (2.79 $\log_{10}$ cfu/cm²) in the average mean score (table 4.20). The reason for this drop was the implementation of the seven HACCP principles, and further assistance provided on the personal hygiene. After the implementation of HACCP personnel had no excuses to avoid hand washing since all premises had a sufficient number of facilities for cleaning, drying, and disinfecting hands, as near as possible to the work stations. All hand washing basins were appropriately marked to remind personnel on the right ways of hand washing. The results indicate that hands to be cleaner after the implementation of HACCP.

The lowest level of contamination (table 4.25) appears during the 3rd surface swab test (2.68 $\log_{10}$ cfu/cm²), performed in level 4 (table 3.1) after implementation of HACCP. Results from examining the differences between the two tests indicate no significant differences with a p=0.349 (table 4.28). The increase in cleanliness was probably due to the fact that the enterprises applied the seven HACCP principles. Personnel were familiar with the microbiological hazards that could be transferred to food through cross contamination, and they tried to eliminate them. Surfaces were found to be less contaminated after the implementation of HACCP. Guidance was given on cleanliness of the surfaces following PRPs and HACCP principles. Personnel were advised to focus on high priority cleaning of surfaces for food preparation in order to prevent bacteria spread. Inadequate cleaning of surfaces represents a hazard for cross contamination through the spread of bacteria during food preparation.

The results of the 3rd food analysis were the same (6%) as the results of the 2nd food analysis (Figure 4.16). Analysis was performed at the end of level 4 after the implementation of the seven HACCP principles. Improvement was observed between the 1st and 2nd food analyses, where dramatic changes took place concerning cleaning, personal hygiene, and changes in building and facilities. Between the 2nd and 3rd food analyses personnel were advised on HACCP principles. The food sample results didn’t show any measurable differences in food safety levels as a result of implementing HACCP. As discussed at the beginning of section 5.2.3 the food cross contamination varies throughout the food preparation period and between premises. Any statistically valid improvements are difficult to be determined due to this variability.

Concerning the 3rd microbiological and chemical water analyses, there was a small increase in the number of violations compared to the 2nd water analysis evaluation (tables 4.17 and 4.18). This was due to the fact that all enterprises were using the water provided by the government.

5.2.3.3 Analyses HACCP / CYS244

This section discusses the results of the analyses in the microbial contamination of surfaces, hands and food safety after the implementation of CYS244 and compares the results to the HACCP evaluations.

Results in table 4.23 show no significant difference (p=0.638) in the mean scores of the hand swab tests after the implementation of HACCP compared to the mean scores after the implementation of CYS244. In the 4th hand swab test, performed in level 6 after the implementation of CYS244, there was a small increase, from 2.79 to 2.80 $\log_{10}$ cfu/cm², in the average mean score (table 4.20). In this level of the implementation, the system was applied in a more complicated way by entering into more details and by applying the requirements of CYS244. As a result, some of the procedures concerning the personal hygiene, including hand washing, stopped. Literature suggests that negative attitude acts as a barrier on the implementation of food safety systems (Azanza and Zamora-Luna, 2005; Panisello and Quantick, 2001). Personnel returned to their old habits decreasing the frequency of hand washing.

The mean score (table 4.25) of the 4th surface swab test indicates an increase in the level of contamination (2.87 $\log_{10}$ cfu/cm²). That increase in the level of contamination was also due to the negative attitude of the personnel towards the system as it became more complicated and difficult to implement.

Concerning food analyses, in the 4th food analysis there was an increase to 8.8% of the total violations compared to the 3rd food analysis (Figure 4.16). The 4th food analysis was performed in level 6 after the implementation of CYS244 where personnel had a negative attitude towards the system as discussed in section 5.2.2.

One of the violations concerned a seafood salad in a tavern which was made of avocado, lettuce, shrimps, and mayonnaise. High levels of *coliforms* (6000 cfu/g) and *Clostridium perfringens* (1000 cfu/g) were detected. This may have been due to contamination by hand during preparation or due to inappropriate temperature during the preparation or display temperatures. The analysis was performed after the implementation of CYS244 when personnel started to have a negative attitude towards the system. They had been advised to wash hands when arriving and leaving the workplace, before and after direct contact with food, after using the toilet, before and after eating and smoking, and after removing protective clothing and gloves. After personnel developed a negative attitude they were washing their hands only when arriving at the workplace and after using the toilet. That change in hygiene practices affected the food safety. In one of the bakeries, *Staphylococcous aureus* was detected in a chicken pastry (80 cfu/g, Appendix B3). Again this was probably due to the personal hygiene of the personnel. Inappropriate hand washing is a hazard for food contamination, as effective hand washing will remove 90-95% of microorganisms (Hawker *et al*., 2005).

Concerning microbiological and chemical water analyses, figures 4.17 and 4.18 present the violations showing a small decrease in the number of violations of the 4th microbiological and chemical water analyses compared to the 3rd evaluation of water analyses.

5.2.3.4 Analyses CYS244 / ISO22000

This section discusses the results of the analyses in the microbial contamination of surfaces, hands and food safety after the implementation of ISO22000 and compares the results to the CYS244 evaluations.

The results in table 4.23 show a significant difference (p=0.010) in the mean scores of the hand swab tests after the implementation of ISO22000 compared to the mean scores after the implementation of CYS244. In the 5th hand swab test, performed after the implementation of ISO22000 (level 8, table 3.1), there was an increase in the mean score (3.03 $\log_{10}$ cfu/cm²) as shown in table 4.20. This increase was due to the negative attitude that the personnel developed towards the new complicated form of the system after the transition from CYS244 to ISO22000.

The mean score of the 5th surface swab test, performed after the implementation of ISO22000, showed an increase in the level of contamination (2.96 $\log_{10}$ cfu/cm²) compared to the 4th surface swab test (table 4.25). This high number of TVC suggests that bacteria are not being well controlled due to pure cleaning and cross contamination. The negative attitude of the personnel towards the system acted as a barrier for the cleaning procedures.

In the 5th food analysis there was a further increase in the number of violations reaching 10.8% of the total violations (Figure 4.16). The percentage of total violations was higher than the 1st food analysis performed before any intervention. Food management systems are a good way to improve food safety when they are in a simple form and personnel are able to use and understand, implement and maintain them. When the system becomes complicated and difficult to understand and implement, there isn't any improvement in food safety. Results show clearly that at the beginning there was a decrease in the food violations, after the implementation of PRPs (figure 4.16). Stability was observed after the implementation of HACCP. When the system started to be more complicated an increase in food violations were observed.

An example of a violation after the implementation of ISO2200 included samples of mince meat with high levels of TVC. Most probably the sample was contaminated from the knives and the equipment during the preparation. Inadequate cleaning and disinfection of all surfaces and equipment is essential in order to avoid cross contamination. A sample of processed pork had also been identified with high levels of TVC most probably due to the inappropriate cleaning of equipment or temperature during the preparation or the display of the product. The above food analysis was performed after the implementation of ISO22000 when personnel had already developed a negative attitude towards the system. At this point they stopped the cleaning procedures, the personal hygiene procedures and the hazard control procedures and they returned to their old habits.

Concerning microbiological and chemical water analyses, figures 4.17 and 4.18 present the observed violations. There is no change in the number of violations from the 4^{th} to the 5^{th} microbiological analysis, but there is a small increase in the chemical water analysis.

5.2.4 Knowledge

For a company to implement a food management system, knowledge of food safety is required. As stated in the literature, most food handlers in catering lack basic food safety knowledge (Bas *et al.*, 2006; Worsfold and Griffith, 2003). Little *et al.* (2002) found that in premises where managers did not have adequate food hygiene training a higher number of unsatisfactory food samples were observed compared to those who had adequate training. Azanza and Zamora-Luna (2005) recognized that knowledge is influenced by awareness, familiarity, and comprehension. Youn and Sneed (2002) identified that to provide training enterprises needed to invest in time and money. Especially for SMEs that have a small number of employees, time is a barrier for the training of personnel. That was a limitation for this research since personnel could not take a whole day off and thus personnel had to split in groups.

To increase personnel's knowledge in food safety practices, training (levels 2 and 6) and coaching (levels 3 and 8) was provided. Two sessions of training were performed, the first one during the implementation of PRPs (level 2) which was a hygiene training, and the second during the implementation of CYS244 (level 6) which was on CYS244 requirements and process training. At the end of each training session a test was applied to identify personnel's level of awareness. In total three tests were performed (Test1-Test3). Test1 was given to the personnel before any intervention, Test2 after the training session on PRPs, and Test3 after the training session on CYS244. The tests consisted of two parts: Part A which was the same for all three tests, and Part B which was different over the three tests as described in chapter 3, section 3.7.4.

5.2.4.1 Test before any intervention / PRPs

Test1 was performed to check if the employees had basic knowledge of food safety. A significant difference was found after comparing the mean scores between parts A of the two tests (table 4.34). As presented in tables 4.32 and 4.35, there was an increase in the mean scores of Parts A and B from Test1 to Test2 from 3.97 to 8.59 and from 5.23 to 7.49 respectively. Even if Part B was different through the three tests, the comparison was made on the total score of the questions evaluating the understanding and knowledge of the employees. The mean scores of Test1, performed before any intervention, were low with 3.97 for part A and 5.23 for part B. Respondents answered incorrectly most of the questions of part A of Test1, before any intervention, concerning HACCP and food safety. It was noted that there was confusion among the personnel regarding what the PRPs and HACCP system was about, what were the demands and its flexibility, and what the requirements of the legislation. An increase in the mean scores of Test2, performed after the implementation of PRPs, was observed. A training session during the implementation of PRPs was provided to all personnel involved on the implementation of the system. The training included basic information on food hygiene, personal hygiene, cleaning, cooking, and cross contamination. It was designed by the researcher as described in section 3.7.4, was carried out in-house by the researcher using training manuals. Visual images were given in all the enterprises outlining practices such as hand washing messages, temperature control, etc. Part of the training involved on-the-job training, particular to each individual's responsibilities. Mortlock *et al*. (2000) and Hendry *et al*. (1991) suggested on-the-job training as the most adequate approach. After training was achieved, people had to study the manuals and take Test2, in which most of the trainees performed well. After explaining the food safety issues at the training, all of the personnel answered the same question regarding the food safety issue correctly. The general level of knowledge was high in Test2. The results suggest that the training on PRPs and the guidance in food safety resulted in an increase of personnel's knowledge.

5.2.4.2 Test PRPs / CYS244

This subsection presents the knowledge results of Test3 which was performed after the implementation of CYS244 and can be compared to the results of the Test2 which was performed after the implementation of PRPs. During the implementation of CYS244 the enterprises had moved into a more complex form of the system. After the second training on CYS244, Test3 was performed.

A significant difference was found in the mean scores between the Part A of Test2 and Test 3 (table 4.34). The results of Part A of Test3 show an increase in the mean score (9.41) compared to the mean score of Part A of Test 2 (8.59) (table 4.32). In Part A of Test3 results were better than the previous two tests since Part A was the same over the three tests and did not include any questions concerning CYS244. Respondents answered the same questions correctly as they recognized the right answer; due to (i) they had increased knowledge in food safety after the implementation of food management systems, and (ii) some of them remembered the answers to the questions as they had already taken the test twice. All answers in part A of Test3 were extended and personnel used all the information about food safety that they learn through the training on PRPs and the coaching on HACCP.

The results for Part B, connected to the training session on CYS244, were less good as in Part A, with a decrease in the mean score from 7.49 to 6.16 (table 4.35). That was due to the difficulty of the personnel to understand HACCP terminology and the terms and definitions of CYS244. During the implementation of CYS244 training was performed on HACCP terminology and the application of CYS244. Respondents could not understand biological hazards and HACCP terminology. Results of Part B of the test support the fact that personnel did not understand the HACCP principles, the microbiological hazards, the identification of CCPs, and the CYS244 requirements. Respondents believed it was hard to understand the microbiological hazards due to their limited knowledge in biology and it was also hard to remember all the CYS244 requirements. As stated in the literature, the lack of knowledge in microbiological hazards can cause an incorrect risk assessment

(Panisello and Quanitck, 2001; Taylor and Kane, 2004). For a HACCP system to be properly implemented, employees needed to understand the identification of hazards and especially the microbiological hazards. That lack of knowledge on microbiological hazards confused personnel in the definition of a CCP. Mortimore (2001) recognized the personnel's confusion on determining CCPs.

Respondents were confused with CYS244 requirements and terminology. They did not have an understandable definition of validation, traceability, corrective action, management review, HACCP evaluation, and management food policy, and they could not remember all HACCP terminology. Although the general knowledge on HACCP terminology was low, comparing this knowledge with the audit results and the environmental samples, there seems to be a difference in knowledge and food safety. Personnel don't need to be able to use the correct terminology to be able to produce safe food. The production of safe food is based on the knowledge of food safety issues and PRPs but not on terminology and term definitions. It is necessary for the evaluation of hazards and identification of CCPs to have knowledge of food hygiene. Personnel don't need to remember all the terminology and definitions in order to evaluate hazards, to identify CCPs and to produce safe food. Overall, personnel felt more confident with PRPs and HACCP than with CYS244 and ISO22000.

5.3 Comparison by Activity of Enterprise

The study population consisted of restaurants, fast foods, catering, traditional taverns, confectionaries, butcheries and bakeries. Based on the type of the enterprise the following subgroups were created according to their products:

1. Restaurants (includes restaurants, taverns and coffee/restaurants)
2. Fast foods (includes fast food and catering)
3. Bakeries (includes confectionaries and bakeries)
4. Butcheries (includes butcheries and a small delicatessen factory)

A comparison was made between the above groups to determine any differences in hands hygiene, surfaces cleanliness, and food safety (environmental and food samples).

5.3.1 Before any intervention / PRPs

This subsection compares the different types of food premise, before any intervention and after the implementation of PRPs, regarding the environmental and food samples.

Concerning the level of bacteria on hands, table 4.24 shows that enterprises dealing with raw food (butcheries) have a higher level of contamination compared to those dealing with cooked food (restaurants or bakeries). Premises with large amounts of raw meat were expected to have high levels of TVC. Smith *et al.* (2002) found significant differences in bacterial counts after HACCP implementation in butchers' premises in Birmingham. Different acceptable levels for microbial count were set for the ready to eat foods than for the raw food. The relevant pathogens and indicators that had to be tested for each food category are provided in the guide of "Microbiological Criteria for Food" of the general chemical state laboratory in Cyprus (General chemical state laboratory, 2001) (Appendix B5), and the Commission regulation (EC) No.1441/2007 on microbiological criteria for foodstuffs.

As shown in table 4.24 the highest level of contamination (3.98 $\log_{10}$ cfu/cm^2) is in the butcheries and the lowest (2.87 $\log_{10}$ cfu/cm^2) in bakeries. Foods like raw meat and salads have naturally high levels of contamination while flour and sugar have low levels of contamination. Even if the meat is going to be cooked after all in order to be ready for consumption, when it is raw has higher contamination levels. Personnel handling salad and raw meat (restaurants and butcheries) had a higher contamination level than personnel handling with flour (bakeries). For that reason butchers had to clean more diligently, control cross contamination better, and wash their hands more thoroughly than a baker who is handling flour and sugar. Personnel in restaurants appeared to had higher level of contamination (3.11 $\log_{10}$ cfu/cm^2) than the personnel in bakeries (2.87 $\log_{10}$ cfu/cm^2). One of the reasons personnel working in restaurants appear to have a higher level of contamination than the personnel working in bakeries was that they were handling salads and high risk food. They also had to prepare a large number of meals quickly and under pressure in order to manage to serve all their clients. Personnel working in fast food appear to have a higher level of contamination (3.35 $\log_{10}$ cfu/cm²) than personnel in restaurants (3.11 $\log_{10}$ cfu/cm²) but still lower than butcheries (3.98 $\log_{10}$ cfu/cm²). Personnel in fast food were working continuously to prepare ready to go food as clients were waiting. Due to time constraints there was not enough time to think of hand washing, and that was the reason for the higher level of contamination in their hands compared to restaurants.

There was a decrease in contamination identified by the hand swab test for all four groups of premises after the implementation of PRPs. The high number of TVC suggests that bacteria are not being well controlled due to pure cleaning and cross contamination. More specifically

- Personnel dealing with raw food had a higher number of bacteria on their hands than personnel working in enterprises dealing with cooked food.
- Personnel in bakeries that were not handling high risk foods and didn't work under pressure had a lower number of bacteria in their hands.
- Personnel working in enterprises that were handling high risk foods had higher numbers of bacteria in their hands as they didn't have time for hand washing as often as they needed.

The enterprise's activity, the food that personnel were handling, and time limitations, are parameters that are directly connected with the personal hygiene of the personnel.

Examining the surface swab tests according to the activity of the enterprise, it can be observed that different enterprises are subject to a different level of contamination. Table 4.29 shows that surface swab test for butcheries had the highest number of bacteria (3.83 $\log_{10}$ cfu/cm²), and bakeries had the lowest level (2.86 $\log_{10}$ cfu/cm²). As explained above, enterprises dealing with raw food had a higher level of contamination than enterprises dealing with cooked food. Surfaces in butcheries had high levels of bacteria as they were handling raw meat that naturally had high levels of contamination. Surfaces in bakeries had a lower level of bacteria since bakeries handle flour and sugar that don’t have high levels of contamination. Fast food enterprises had a higher level of contamination than restaurants due to time limitations and the pressure for preparing food. In contrast, bakeries had more time to clean, thus the level of contamination was lower. For this reason they could comply with the cleaning schedule more easily than restaurants and fast foods. Fast food enterprises tended to clean every day after closing and not during the day. When asked the reason for this they mentioned time and pressure due to the type of their job. Panisello and Quantic (2001) proposed similar views on time related restrictions. There was a decrease in the results of the surface swab test for all four groups of premises after the implementation of PRPs. The high number of TVC suggests that bacteria are not being well controlled due to pure cleaning and cross contamination in the groups of restaurants, fast foods and butcheries.

Table 4.30 gives the number of food violations. As shown in the table restaurants had the highest number of violations (8 violations), and fast food the lowest (1 violation). Restaurants appear to have more violations in food analyses since they offer a bigger range of different foods and they handle higher risk foods. Restaurants and taverns in Cyprus, especially the traditional ones, serve a range of small dishes with traditional food called “meze”. These small dishes include different kinds of food and sauces which were included in the high risk food, and also cooked food and cold food (salads) at the same time. It can be noted that in UK and elsewhere, food service premises like restaurants also have the highest risk of causing food poisoning (Jones and Angulo, 2006). Fast foods were preparing a smaller range of food using ready manufactured sauces.

Bakeries and butcheries had less violations than restaurants. Butcheries had less violation even if they had higher levels of contamination as their products are not ready-to-eat food. The level of contamination has to do with the cleaning and disinfection and personal hygiene thus violations are about food safety. Bakeries were handling foods that are not considered high risk, unlike restaurants that were handling salads and had to prepare different kinds of creams and sauces. Bakeries also had standard production procedures since the range of their products is standard. Comparing the food samples and the hands and surface swab samples the results are opposite. In the case of cleaning and personal hygiene butcheries had the highest level of contamination, but in food violations restaurants had the highest number of violations.

After the implementation of PRPs there was a decrease in the number of food violations for bakeries and butcheries from 6 to 3. Restaurants and fast foods had the same results, 8 and 1 respectively. This was due to their every day work and the fast moving environment that personnel had to work, and as a result they were facing more difficulties than bakeries and butcheries in applying the new procedure required of PRPs.

5.3.2 PRPs / HACCP

This subsection compares the different types of food premise, after the implementation of PRPs and after the implementation of HACCP, regarding the environmental and food samples.

As shown in table 4.24 the highest level of contamination appears to be in the butcheries (3.42 $\log_{10}$ cfu/cm²) and the lowest (2.42 $\log_{10}$ cfu/cm²) in bakeries. Personnel in restaurants appeared to have a higher level of contamination (2.74 $\log_{10}$ cfu/cm²) than those in bakeries (2.42 $\log_{10}$ cfu/cm²). Personnel working in fast food appeared to have a higher level of contamination (2.98 $\log_{10}$ cfu/cm²) than personnel in restaurants (2.74 $\log_{10}$ cfu/cm²), but still lower than butcheries (3.42 $\log_{10}$ cfu/cm²). Table 4.29 shows that the surface swab test for butcheries had the highest number of bacteria (3.24 $\log_{10}$ cfu/cm²), and bakeries had the lowest level (2.26 $\log_{10}$ cfu/cm²). As explained above, enterprises dealing with raw food had a higher level of contamination than enterprises dealing with cooked food. Fast food enterprises had a higher level (2.86 $\log_{10}$ cfu/cm²) of contamination than restaurants (2.70 $\log_{10}$ cfu/cm²).

Table 4.30 gives the number of food violations. As shown in the table restaurants had the highest number of violations (8 violations), and fast food the lowest (1 violation). Bakeries and butcheries had less number of violations than restaurants, with 4 and 2 violations respectively. After the implementation of HACCP there was a decrease in the number of food violations for butcheries from 3 to 2 and an increase in bakeries from 3 to 4. Restaurants and fast foods had the same results of 8 and 1 violations respectively.

5.3.3 HACCP / CYS244

This subsection compares the different types of food premise, after the implementation of CYS244, regarding the environmental and food samples.

As shown in table 4.24 the highest level of contamination appears to be in the butcheries (3.44 $\log_{10}$ cfu/cm²) and the lowest in bakeries (2.38 $\log_{10}$ cfu/cm²). Personnel in restaurants appeared to have a higher level of contamination (2.80 $\log_{10}$ cfu/cm²) than the personnel in bakeries (2.38 $\log_{10}$ cfu/cm²). Personnel working in fast food appeared to have a higher level of contamination (2.94 $\log_{10}$ cfu/cm²) than personnel in restaurants (2.80 $\log_{10}$ cfu/cm²) but still lower than butcheries (3.44 $\log_{10}$ cfu/cm²).

After the implementation of CYS244 there was an increase in the mean scores in all of the surface swab tests of the four groups of the premises. Table 4.29 shows that the surface swab test for butcheries had the highest number of bacteria (3.45 $\log_{10}$ cfu/cm²), and bakeries had the lowest level (2.51 $\log_{10}$ cfu/cm²). Fast food enterprises had a higher level (2.96 $\log_{10}$ cfu/cm²) of contamination than restaurants (2.86 $\log_{10}$ cfu/cm²).

Table 4.30 gives the number of food violations, in which an increase is observed in food violations for all of the four groups of premises. As shown in the table restaurants had the highest number of violations (9 violations), and fast food the lowest (2 violation). Bakeries and butcheries had less number of violations than restaurants, 6 and 5 respectively.

5.3.4 CYS244 / ISO22000

This subsection compares the different types of food premise, after the implementation of ISO22000, regarding the environmental and food samples.

After the implementation of ISO22000 there was a sharp increase in the mean scores of hand swab tests for all of the four groups of premises. As shown in table 4.24 the highest level of contamination appears to be in the butcheries (3.57 $\log_{10}$ cfu/cm^2) and the lowest in bakeries (2.71 $\log_{10}$ cfu/cm^2). Personnel in restaurants appeared to have a higher level of contamination (2.97 $\log_{10}$ cfu/cm^2) than those in bakeries (2.71 $\log_{10}$ cfu/cm^2). Personnel working in fast food appear to have a higher level of contamination (3.22 $\log_{10}$ cfu/cm^2) than personnel in restaurants (2.97 $\log_{10}$ cfu/cm^2) but still lower than butcheries (3.57 $\log_{10}$ cfu/cm^2).

An increase was observed in three of the surface swab tests concerning fast foods, bakeries and butcheries, and a small decrease was observed in restaurants. The decrease in restaurants was due to the premise that closed down. Table 4.29 shows that the surface swab test for butcheries had the highest number of bacteria (3.62 $\log_{10}$

cfu/cm²), and bakeries had the lowest level (2.68 $\log_{10}$ cfu/cm²). Fast food enterprises had a higher level (3.07 $\log_{10}$ cfu/cm²) of contamination than restaurants (2.85 $\log_{10}$ cfu/cm²).

Table 4.30 gives the number of food violations, from which an increase was observed in food violations for the three groups of premises, fast food, bakeries, and butcheries. Samples were stable for the restaurants group. As shown in the table, restaurants had the highest number of violations (9 violations), and fast food the lowest (3 violation). Bakeries and butcheries had less number of violations than restaurants, with 8 and 7 violations respectively.

5.4 Cost

Cost implications were considered important in all of the enterprises since each enterprise had to spend a considerable amount of money ranging from €3.000 to €30.000 in order to apply the food management systems. Literature suggests that these costs include consultancy, training, investment in infrastructure and equipment, professional management, and product testing (Ehiri *et al.,* 1995; Henson *et al.,* 2000; Bata *et al.,* 2005). In this study, costs were split in two categories. The first category had to do with the cost of the implementation which includes consultation, purchase of manuals, training, and procedural changes. The second category included the cost of infrastructure which includes equipment and the changes to the building and facilities that each enterprise was obligated to do according to the requirements of the food management systems as described in 3.7.5.

Literature reported that the infrastructure and food safety practices that the enterprises have prior to the implementation of the system influence the costs that the enterprise have to invest for the development of the system (Martin and Anderson, 2000; Henson *et al*., 2000).

5.4.1 Cost PRPs

In this subsection the cost of the application of PRPs is presented. Data included purchase of equipment and all the building and facilities changes that the premises had to do due to the PRPs requirements. Costing was calculated at the end of the implementation of the system. The training and guidance on PRPs was provided free to the enterprises. Most of the enterprises were asked to make changes in building and facilities as described in section 5.2.1.1. These changes included both expensive and inexpensive items such as floors, rest rooms, hand washing basins, cutting boards, temperature probes, employees supplies e.g. hats and aprons etc. Results suggest that enterprises invest in making these changes. Table 4.36 gives the cost of applying PRPs including the building and facilities changes that each enterprise was obligated to do according to the requirements of the system. From the table the cost ranges from €1200 to €30000.

5.4.2 Cost HACCP / CYS244 /ISO22000

There was an increase in the cost when HACCP was implemented. Parts of the cost included consultation, training, purchase of manuals, professional guidance, coaching of the HACCP team, pest control, calibration services, and audits and maintenance of the system. These costs were collected from the consultancy offices from the researcher's background in Cyprus. The cost for the implementation of the HACCP, CYS244, and ISO22000 system was calculated according to the hours spent on the development of the system. This was charged using a cost of €65/hour. From table 4.36 the cost for implementation ranges from €3000 to €27000. Enterprises had extra costs due to the additional time needed to implement the system. None of the premises hired any new employees and all the extra work caused from the implementation of the system, was carried out from the same personnel. All of the enterprises complained that the implementation of HACCP, CYS244, and ISO22000 were time consuming and they needed extra staff. Due to costs it was impossible for them to hire extra staff.

None of the enterprises had any contract for pest control, calibration, or product testing (laboratory analyses). Pest control and calibration services were included in the costs for the implementation of the HACCP (table 4.36). Laboratory analyses were an extra cost for each enterprise, depending on the number of products there were testing. After implementation of the system, maintenance costs are required each year e.g. for a third party audit from a certification body. That cost was extra for each enterprise and it was not included in the implementation costs as it was charged by the certification body that the enterprise had the contract with. The cost of the implementation and maintenance of a food management system is high and it is legally required. At the moment in Cyprus there is not any motivation (e.g. star ratings scheme) for the enterprises to promote better quality due to HACCP implementation.

Colatore and Caswell (2000) calculated the total cost of the first year of HACCP implementation in the seafood industry on $113.500-169.000 per premise. FDA‘s estimation in the same food industry was $25.900 per premise. The difference was due to the fact that FDA based their estimation on simple HACCP plans.

All enterprises had economic concerns related to the high cost of implementation and operation of the system. Based on the enterprises’ size it was impossible for them to spend such an amount of money compared with their turnover. A small family based enterprise needed additional financial resources in order to support the cost required for HACCP implementation. These enterprises were private family enterprises and not public enterprises, so they could not raise money from shareholders. SMEs based their turnover on their everyday production and sales. Their profits are based on the number of products they sell to their customers. Most of the enterprises took long term loans to pay the cost of the implementation of the food management systems. Only one of the enterprises closed down as it could not cope with the costs. Unnevehr and Jensen (1999) suggest that in the long term the cost of wastage and recalls will be minimized, but the small enterprises may not be in a position to carry such expenditure over the long term as turnover is often small and they need the money right away to operate.

Food management systems’ benefits could be achieved with lower costs if the implementation was based on a simpler form of HACCP plan. The more complicated the system is, the more expensive it is. Based on the results and given the improvement in audits, tests, environmental and food samples, after the implementation of the CYS244 and ISO22000, the expenditure was not appropriate. Calculating the cost of the implementation of the food management systems, enterprises spend a lot of money and at the end they didn't have any improvement in food safety. At the end, after the implementation of PRPs, HACCP, CYS244, and ISO22000, most of the personnel went back to previous practices. Enterprises could not detect and quantify the impact of the implementation of the food management systems in their premises. Maldonado *et al.* (2005) also identified this problem. For SMEs these costs represent a greater proportion of their turnover than for a large enterprise. Figure 4.21 presents the number of employees compared to the cost of the implementation. The cost increases when more people are involved in the implementation of the system. Large enterprises could easier perceive the system as a cost effective tool. In order to examine this further, economic research is required comparing the costs and savings. Adams and Moss (2000) supported that savings are difficult to calculate as foodborne illnesses are difficult to estimate.

5.5 Future Work

Future work is needed regarding the food management systems in SMEs in Cyprus to investigate whether there are benefits in having such systems in place in the long run. Some possible points of future work include:

1. At the end of the research most of the enterprises stopped the procedures

required by the food management systems and personnel went back to previous practices. A revisit at the 49 enterprises that completed the research is recommended in order to monitor the performance in food hygiene practices. The same evaluation procedures may be used in order to evaluate their performance and whether any hygiene practices obtained through the study are still in place.

2. A further economic research is required to compare the costs and savings and whether SMEs consider the food management systems as a cost effective tool in the long term, and whether the investments required for the implementation of the systems justify the benefits.

3. Environmental and food samples data were variable due to the different types of enterprises. In a future work the sample group is recommended to include the same type of enterprises. Environmental samples were tested only for TVC. Testing for *enterobacteriaceae* and *coliforms* is recommended to be considered in future work to determine the cleanliness on surfaces and hands.

5.6 Conclusions

SMEs made the biggest improvement in food safety and hygiene practices when they implement the PRPs and a simple form of HACCP plan. After the application of CYS244 and ISO22000 when the system became more bureaucratic and complicated, the enterprises tended to develop a negative attitude towards the system. By the end most of them stopped the procedures required by the food management systems. What was left from the system were the changes to the building and facilities and a slight improvement in cleaning. A complicated form of the food management system was not found to worth the cost and difficulties that the SMEs faced during the implementation. The same results could be achieved with PRPs and a simple form of HACCP.

Foodborne illnesses and outbreaks can be controlled with the hygiene practices and control of food safety. Factors such as temperature control, control of cross contamination, cleaning of premises and equipments, and personal hygiene, need to be controlled. SMEs can control these factors and avoid outbreaks with the application of PRPs and a simple form of HACCP.

6 CONCLUSIONS

6.1 Introduction

Food management systems are based on prevention by identifying where in the process the hazards are likely to occur and control them. HACCP is part of the food management systems and had been published by Codex, WHO and NACMCF. It is applicable throughout the food supply chain from raw material production through processing and distribution to final use by the consumer.

HACCP principles aim to identify the hazards that are likely to occur at any stage in the food supply chain and control them. The main benefit of the system is the prevention of these hazards and the production of safe food. To develop a successful HACCP system, enterprises are required to apply PRPs, and personnel to understand what constitutes a food safety hazards and how to control it. The essential control measures include temperature control and prevention of cross contamination.

In order for the food enterprises to produce safe food, HACCP was introduced into regulation (EC) 852/2004. Cyprus harmonized with the European legislation in 2004 when it joined the European Union. SMEs in Cyprus experience difficulties in implementing the new legislation and especially HACCP due to the lack of technical expertise and financial constraints. The aim of the study was to assess whether the implementation of food management systems improved the hygiene and food safety in SMEs in Cyprus.

6.2 Methodology

The research sample included 50 small food enterprises in Cyprus that didn't have the HACCP system in place by the time of the research. Measurements on hygiene levels, knowledge, food safety, cleanliness, and the attitude of personnel towards the system were performed throughout the implementation procedure of the system. The first approach was through a visit to their premises. Hotels, food chains, hospitals, schools and elderly homes were excluded from the research sample.

The research was divided into different levels (table 3.1). During each level new procedures concerning the system were added, starting from the PRPs through the fully application of the ISO 22000. Throughout the different levels, evaluations were performed with the use of audit check lists, questionnaire, laboratory environmental and food analyses, and tests of the personnel, in order to measure the parameters mentioned above.

6.3 Results and Discussion

At the end of the research 49 of the enterprises participating completed the full program. The reason enterprises didn't drop out of the project was due to the fact that most of them needed a HACCP certificate in order to get the government funding.

What is more, these families were in the food business most of their lives and were emotionally attached to their work. This is in contrast to a research conducted in UK catering where 30% of the study group closed during the project (Acosta, 2009).

The implementation of PRPs was achieved through personnel's training. After the intervention there was a significant difference in the levels of cleanliness, knowledge, food safety, personnel attitude, and hygiene practices. Improvements were found when the enterprises had in place a simple form of PRPs and HACCP system that they could understand and implement. The knowledge of the personnel was improved after the training as personnel understood PRPs.

There was an improvement concerning hygiene practices as more enterprises were storing displaying and cooking food at the correct temperatures. Improvements were found in the inspection of the incoming goods and in the cleaning procedures. The training increased the awareness of personnel in temperature monitoring. Personnel developed a positive attitude towards the system as they believed it was helpful and could prevent any customer complaints, and could also protect them from due diligence. Personnel accepted and understood PRPs. Due to those improvements, better results were observed in environmental and food samples after the implementation of PRPs and the simple form of HACCP. The level of contamination varies throughout the different stages of food preparation, and between different premises. When the enterprises were categorized in groups according to their activities, butcheries were found to have the highest levels of contamination in the environmental samples and bakeries the lowest. Restaurants had the highest number of violations in food samples analyses. Butcheries tended to have higher levels of contamination because they were dealing with raw food and this was entirely expected, and bakeries had the lowest levels of contamination as they were handling flour and sugar that they naturally have low levels of contamination. Restaurants had the highest number of violations concerning the food analysis due to the large amounts of meals including salads, sauces, and a mixture of cold and hot food. The above results suggest that the implementation of a simple food safety management system improved the hygiene and food safety in SMEs in Cyprus.

This was up to level 4 where they had implemented PRPs and the seven principles of the HACCP system in a simple form. After level 4, when the system started to become more complicated and enterprises implemented the CYS244 and ISO22000, there was a decrease in the improvements. There was a significant difference in the levels of cleanliness, knowledge, food safety, personnel attitude, and hygiene practices. There was a decrease in the improvement concerning hygiene practices as more enterprises stopped the procedures of storage, display, and cooking food at the correct temperatures. No improvements were found in the inspection of the incoming goods, and a decrease was observed concerning the cleaning. After the second training their knowledge had a marginal improvement as they could not understand the more complicated terms, conditions, and procedures, required by CYS244. Complexity of the system was not the only reason of the decrease in the improvements. Personnel developed a negative attitude towards the food safety management systems. Personnel in the enterprises were tired to all these changes. For this reason they developed a negative attitude towards the system, they fed up all these changes, and there was a lack of motivation. That influenced the environmental and food samples as there was an increase to the number of violations.

Personnel were complaining for the extensive documentation and the record keeping. By the end of the research the enterprises stopped the application of the procedures and record keeping that was required by the system. After all this effort from the enterprises they ended up with no active, workable HACCP system. By the end of the research, what was left from the system was the changes in building and facilities, a slight improvement in cleaning, and the knowledge that the personnel gained from the training. Cost was an additional and unwarranted barrier as each of the enterprise had to invest a considerable amount of money ranging from approximately €3.000 to €30.000 in implementing the food safety management systems. At the end of the research all of the enterprises spent a large amount of money and the benefits that they got were limited as most of them returned back to their old habits. Just using the PRPs is a cost effective way to reach an acceptable level of safety (Acosta, 2009). Personnel's attitude over the different levels of the research changed from positive to negative. Generally speaking the enterprises could comply with a simple form of the system but not with the more complicated form.

6.4 Conclusions

From the study it appears that an enterprise can apply the system up to a specific complexity limit. In the case of the SMEs under study, exceeding this complexity limit of the system resulted in negative results (termination of the system). In order for the food safety target of HACCP implementation to be accomplished flexibility of the system must exist. The implementation of PRPs and a simple form of HACCP system improved the hygiene and food safety of the SMEs in Cyprus. When an enterprise implements a simple form of the system, there are benefits for the enterprise in having the system in place, and the investments required for successful implementation justify the benefits. In order for SMEs to have in place a workable HACCP system, a generic, simple, and flexible HACCP system is required to ensure that all the requirements of the system are satisfied. Check list approaches, booklets devised for record keeping, and a simple diary could be more suitable for this group of enterprises. For SMEs requiring a certification, a new simple standard that will not include management and communication procedures can be created.

As an over conclusion, SMEs can be de-motivated by applying a complex form of the system. SMEs need a simpler form of food management system in order to be able to comply with it and improve the hygiene and food safety in their enterprises. The results of the study have a wider global significance and are applicable to both EU countries and globally in general. SMEs constitute the majority of food enterprises in many countries and are the enterprises facing most difficulties and barriers when implementing food management systems.

REFERENCES

Acosta, N., 2009. *Evaluation of the effectiveness of HACCP and prerequisite programs PRPs in small catering businesses in Birmingham UK*. PhD thesis, University of Birmingham.

Adams, M.R. & Moss, M.O., 2000. *Food Microbiology*. 2nd Ed. Cambridge UK: Royal Society of Chemistry.

Angeli, I., Apostolou, N., Pouvali, M., & Olympiou, A., 2009. Quality, environmental and food safety management systems: similarities and deficiencies. A case study of three national surveys in Cyprus. In *5th International Working Conference: Total Quality Management*. Belgrade, 1-4 June 2009. Serbia.

Anonymous, 2006. *The Food Hygiene (England) Regulations 2006. Statutory Instrument 2006. No. 14*. UK: HMSO The Statutory Office Limited [online]. Available at: http://www.opsi.gov.uk/si/si2006/uksi_20060014_en.pdf

[Accessed 12 November 2007].

Anonymous, 2004. Regulations (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the Hygiene of Foodstuffs. *Official Journal of the European Union*.

Anonymous, 1998. *Food Safety Information Bulletin*, No 97, MAFF, London.

Anonymous, 1990. *Food Safety Act 1990 (c.16)* [online].

Available at: http://www.hmso.gov.uk/acts/acts1990/Ukpga_19900016_en_1.htm

[Accessed 30 March 2005].

Azanza, M.P.V, 2006. HACCP certification of food services in Philippine interisland passenger vessels. *Food Control,* 17(2), pp.93-101.

Azanza, M.P.V. & Zamora-Luna, M.B.V., 2005. Barriers of HACCP team members to guideline adherence. *Food Control*, 16(1), pp.15-22.

Bas, M., Ersun, A.S. & Kivanç, G., 2006. Implementation of HACCP and prerequisite programs in food businesses in Turkey. *Food Control*, 17(2), pp. 118-126.

Bata, D., Drosinos, E.H., Athanasopoulos, P. & Spathis, P., 2005. Costs of GHP improvement and HACCP adoption of an airline catering company. *Food Control,* 17(5), pp.414-419.

Bauman, H.E., 1995. *The origin and concept of HACCP*. In A. M.Pearson & T.R. Dutson, HACCP in meat, poultry and fish processing. London: Chapman & Hall.

Bender, D.A., 2005. *A dictionary of food and nutrition*. Oxford University Press [online].

Available at: http://www.encyclopedia.com

[Accessed 26 December 2005].

Beumer, R.B. & Kusumaningrum, H., 2003. Kitchen hygiene in daily life. *International Biodeterioration & Biodegradation,* 51, pp.299-302.

Bloomfield, S.F., 2003. Home hygiene: a risk approach. *International Journal of Environmental Health*, 206, pp.1-8.

Bower, C.K., McGuire, J. & Daeschel, M.A., 1996. The adhesion and detachment of bacteria and spores on food-contact surfaces. *Trends in Food Science & Technology,* 7, pp.152-157.

Bryan, F.L., 1996. Another decision tree approach for identification of critical control points. *Journal of Food Protection*, 59(11), pp.1242-1247.

Burau, D., 2007. *The DaVinci code of auditing: Reaching the holy grail of one global standard*. International Association of Food Protection, 94th Annual Meeting. Lake Buena Vista, Fl.

Cates, S.C., Sheryl, C., Morales, R.A., Karns, S.A., Jaykus, L.A., Kosa, K.M., Teneyck, T., Moore, C.M. & Cowen, P., 2006. Consumer knowledge, storage and handling practices regarding listeria in frankfuters and Deli meats: results of a web-based survey. *Journal of Food Protection*, 69(7), pp.1630-1639.

Cato, J.C., 1998. *Seafood safety - economics of hazard analysis and critical control point (HACCP) programmes* [online]. Rome: Food and Agriculture Organization of the United Nations. Available at:
http://www.fao.org/docrep/003/x0465e/x0465e00.HTM
[Accessed 20 November 2005].

Chambers, J.M., Cleveland, W.S., Klein, B. & Tukey, P.A., 1983. *Graphical methods for data analysis.* Belmont, CA: Wadsworth International Group.

Chamber, A., 2008. *Survey " incomplete" but reveals ISO 22000 implementation in 72 countries*. Special Report, ISO Management systems [online].
Available at: http://www.iso.org/iso/specific-applications_food-safety.
[Accessed 26 March 2006]

Cochran, W.G., 1977. *Sampling Techniques.* 3rd ed. New York: John Wiley & Sons.

Codex Alimentarius Commission (CAC), 1997. *Hazard analysis and critical control point (HACCP) system and guidelines for its application.* 2nd ed. In: General

Requirements (Food Hygiene), Supplement to Vol . 1B, FAO/WHO. Rome: FAO/WHO.

Codex Alimentarius Commission (CAC)**,** 1995. *Recommended international code of practice - General principles of food hygiene* (CAC/RCP 1-1969, Rev. 2 (1985)). In Codex Alimentarius, Vol. 1B, General requirements (food hygiene), p, 1-20, Rome, FAO/WHO.

Conover, W.J., 1999. *Practical nonparametric statistics.* 3rd ed. New York: John Wiley & Sons.

Cooper, R.A., Griffith, C. J., Malik, R.E., Obee, P. & Looker, N., 2007. Monitoring the effectiveness of cleaning in four British hospitals. *American Journal of Infection Control*, 35(5), pp.338-341.

Corder, G.W. & Foreman, D.I., 2009. *Nonparametric statistics for non-statisticians: A step-by-step approach*. New York: J. Wiley.

CYS, 2001. *CYS244: Food Management Standard*. Cyprus.

Den Aantrekker, E.D., Boom, R.M., Zwietering, M.H. & van Schothorst, M., 2003. Quantifying recontamination through factory environments – a review. *International Journal of Food Microbiology,* 80, pp.117-130.

Discussion paper on HACCP in small and less developed businesses (CX/FH 98/12), Prepared by the Netherlands and presented at the Codex Committee on Food Hygiene, Orlando, Florida, 26-30 October 1998.

Domenici Roberto, C., Cardoso Brandão, S. C. & Barbosa da Silva, C.A., 2006. Costs and investment of implementing and maintaining HACCP in a pasteurised milk plant. *Food Control,*17(8), pp. 599-603.

EFET, 2004. *Inspectional guide for food establishments* [online].

Available at: www.efet.gr/docs/ΕΝΤΥΠΟ%20ΜΑΖΙΚΗΣ%20ΕΣΤΙΑΣΗΣ.doc

[Accessed 10 November 2005].

Ehiri, J.E., Morris, G.P. & McEwen, J., 1995. Implementation of HACCP in food business: the way ahead. *Food Control,* 6(6), pp. 341-345.

ELOT 1416, 2000. *Greek standard ELOT - risk assessment hazard analysis critical control points (HACCP),* Greek Standardization Organization.

Engel, D. 1998. Teaching HACCP – theory and practice from the trainer's point of view. *Food Control,* 9(2-3), pp.137-139.

EuC Council Directive 93/43/EEC, 1993. *Official Journal of the European Communities,* No, L175/2, 19.7.93.

Eves, A. & Dervisi, P., 2005. Experiences of the implementation and operation of hazard analysis critical control points in the food service sector. *International Journal of Food Management*, 24(1), pp.3-19.

Færgemand, J., 2008. *The ISO 22000 series: global standards for safe food supply chains.* Special Report, ISO Management systems [online].
Available at: http://www.iso.org/ims
[Accessed 26 December 2005].

FDA, 2001. *HACCP: A state-of-the-art approach to food safety*. Washington, DC. [Online].
Available at: http://www.cfsan.fda.gov/~lrd/bghaccp.html.
[Accessed 26 January 2006]

FDA, 1973. *Acidified foods in hermetically sealed containers.* Washington, DC.

Field, A. P., 2005. *Discovering statistics using SPSS for Windows*. 2nd ed. London: Sage Publications.

Food Service and Inspection Service (FSIS), 2006. Compliance guidelines to control listeria monocytogenes in post lethality exposed ready to eat meat and poultry products [online].
Available at
http://www.fsis.usda.gov/oppde/rdad/FRPubs/97013F/LM_Rule_Compliance_Guidelines_May_2006.pdf
[Accessed 5 November 2007].

Food Service and Inspection Service (FSIS), 2002. *Regulations and directives development. current good manufacturing practices (21 CFR 110)* [online].
Available at: http://www.fsis.usda.gov/OPPDE/rdad/FRPubs/00-014R/fda-gmpregs.htm
[Accessed 10 September 2008].

Friedhoff, R.A., Houben, A.P.M., Leblanc, J.M.J., Beelen, J.M.W.M., Jansen, J.T. & Mossel, D.A.A., 2005. Elaboration of microbiological guidelines as an element of codes of hygienic practice for small and/or less developed businesses to verify compliance with hazard analysis critical control point. *Journal of Food Protection,* 68(1), pp.139-145.

Friedman, M., 1937. The use of ranks to avoid the assumption of normality implicit in the analysis of variance. *Journal of the American Statistical Association*, 32(200), pp.675–701.

FSRIO, 2005. *A focus on hazard analysis and critical control points*.
Available at: http://fsrio.nal.usda.gov/nal_web/fsrio/fsheet.php?id=227
[Accessed 26 January 2006]

FSA, 2007. *Safer food better business programme-milestone evaluation report* [online].

Available at: http://www.food.gov.uk/multimedia/pdfs/board/fsa071204.pdf

[Accessed 14 April 2008].

FSA, 2005. Safer *Food Better Business toolkit*. London: FSA.

FSA, 2002. Extract from the Food Standards agency Guidance on the implementation of microbiological testing and interpretation of results [online].

Available at: http://www.food.gov.uk/multimedia/pdfs/haccpletterguidance.pdf

[Accessed 5 June 2008].

Garrett, E.S. & Hudak-Roos, M., 1991. Developing an HACCP-based inspection system for the seafood industry. *Food Technology,* 45, pp.53–57.

General chemical state laboratory, 2001. *Microbiological criteria for food.* Nicosia.

Giampaoli, J., Clusky, M. & Sneed, J., 2002a. Developing a practical audit tool for assessing employee food handling practices. *The Journal of Child Nutrition & Management* [online].

Available at: http://docs.schoolnutrition.org/newsroom/jcnm/02spring/giampaoli2/

[Accessed 23 April 2007].

Gillespie, I., Little C. & Mitchell R., 2000. Microbiological examination of cold ready-to-eat sliced meat from catering establishments in the United Kingdom. *Journal of Applied Microbiology,* 88, pp.467-474.

Gilling, S.J., Taylor, E.A., Kane, K. & Taylor, J.Z., 2001. Successful Hazard Analysis Critical Control Point Implementation in the United Kingdom: understanding the barriers through the use of a behavioural adherence model. *Journal of Food Protection*, 64 (5), pp.710-715.

Gorder, G.W. & Foreman, D.I., 2009. *Nonparametric statistics for non-statisticians: a step-by-step approach.* New York: J. Wiley.

Gorman, R., Bloomfield, S. & Addley, C.C., 2002. A study of cross-contamination of food-borne pathogens in the domestic kitchen in the Republic of Ireland. *International Journal of Food Microbiology,* 76, pp.143-150.

Green, L.R., Selman, C.A., Radke, V., Ripley, D., Mack, J., Reimann, D.W., Stigger, T., Motsinger, M. & Bushnell, L., 2006. Food worker hand washing practices: an observation study. *Journal of Food Protection,* 69(10), pp.2417- 2423.

Griffiths, A. 2001. HACCP Works: Integrated Food Safety Management for Food Businesses. Highfield Publications.

Griffith, C.J., Malik, R., Cooper, R., Looker, N. & Michaels, B., 2003. Environmental surface cleanliness and the potential for contamination during handwashing. *American Journal of Infection Control,* 31(2), pp.93-96.

Hawker, J., Begg, N., Blair, I., Reintjes, R. & Weinberg J., 2005. *Communicable disease control handbook,* 2nd ed., Wiley-Blackwell.

Hazard Analysis and Critical Control Point system and guidelines for its application, 1997. In "Food Hygiene Basic Texts". Secretariat of the Joint FAO/WHO Food Standards Programme, FAO, Rome.

Hendry, C., Jones, A. & Arthur, M., 1991. Skill supply, training and development in the small-medium enterprise. *International Small Business Journal* 10(1), pp68-72.

Henroid, D & Sneed, J., 2004. Readiness to implement Hazard Analysis and Critical Control Point (HACCP) systems in Iowa schools. *Journal of the American Dietetic Association,* 104(2), pp.180-185.

Henson, S., Holt, G. & Northen, J., 2000. Costs and benefits of implementing HACCP in the UK dairy processing sector. In Unnevehr, L.J. (Ed.). *The economics of HACCP: costs and benefits* (pp.347-364). Minnesota: Eagan Press.

Holah, J.T., Lavaud, A., Peters, W.A. & Dye, K., 1998. Future techniques for disinfectant efficacy testing. *International Biodeterioration & Biodegradation,* 41(3-4), pp.273-279.

Holt, G. & Henson, S.J., 2000. Quality assurance management in small meat manufacturers. *Food Control,* 11(4), pp.319-26.

ICMSF, 1988. *HACCP in microbiological safety and quality.* Oxford: Blackwell Scientific.

Ioannou, A., 1997. *ISO 9000 quality systems the way forward*. Nicosia: Coopers and Lybrand.

ISO, 2005a. *Food safety management systems – requirements for any organization in the food chain* [online].
Available at: http://www.iso.org/iso/catalogue_detail?csnumber=35466
[Accessed 25 April 2007].

ISO, 2005b. *General requirements for the competence of testing and calibration laboratories* (ISO/IEC 17025) [online].
Available at: http://www.iso.org/iso/catalogue_detail.htm?csnumber=39883
[Accessed 25 April 2007].

ISO, 2000. *Quality management systems -- Fundamentals and vocabulary* (ISO 9000:2000).
Available at: http://www.iso.org/iso/catalogue_detail?csnumber=29280
[Accessed 25 April 2007].

Jay, J., Loessner, M. & Golden, D., 2005. *Modern Food Microbiology*. 7th ed. Maryland: Aspen Publishers.

Jensen, H.H. & Unnevehr, L.J., 2000. HACCP in pork processing: costs and benefits. In Unnevehr, L.J., ed. *The economics of HACCP: costs and benefits*. Minnesota: Eagan Press, pp29-43.

Jones, T. & Angulo, F., 2006. Eating in restaurants: A risk factor for foodborn disease? *Clinical Infectious Diseases*, 43, pp.1324-1328.

Jouve, J.L., 2000. Good manufacturing practise, HACCP and quality systems. In: Lund, B.M., Baird-Parker, T.C. and Gould, G.W. ed. *The microbiological safety and quality of food,* Volu*me II,* Maryland:Aspen Publications Inc.

Kennedy, J., Jackson, V., Blair, I.S., McDowell, D.A., Cowan, C. & Bolton, D.J., 2007. The incidence of significant foodborn pathogens in domestic refrigerators. *Journal Food Control,* 18(4), pp.346-351.

Kennedy, J., Jackson, V., Blair, I.S., McDowell, D.A., Cowan, C. & Bolton, D.J., 2005. Food safety knowledge of consumers and the microbiological and temperature status of their refrigerators. *Journal of Food Protection,* 68(7), pp.1421-1430.

Khandke, S.S & Mayes, T., 1998. HACCP implementation: A practical guide to the implementation of the HACCP plan. *Food Control,* 9(2-3), pp.103-109.

Kidd, M., 2000. Food Safety – Consumer Concerns. *Nutrition and Food Science,* 30(2), pp.53-55.

Kusumaningrum, H.D., Riboldi, G., Hazeleger, W.C. & Beumer, R.R., 2003. Survival of foodborne pathogens on stainless steel surfaces and cross-contamination to foods. *International Journal of Food Microbiology,* 85(3), pp.227-236.

Legnani, P., Leoni, E., Berveglieri, M., Mirolo, G., & Alvaro, N., 2004. Hygienic control of mass catering establishments, microbiological monitoring of food and equipment. *Food Control*, 15, pp.205-211.

Little, C.L., Mitchell, R.T., Barnes, J., 2002. Food Standards Agency catering hygiene initiative: Microbiological examination of food from take-aways and *sandwich bars* [online]. Available at: http://www.food.gov.uk/multimedia/pdfs/microexamfood.pdf

[Accessed 24 October 2007].

Maldonado, E.S., Henson, S. J., Caswell, J. A., Leos, L. A., Martinez, P. A., Aranda, G. & Cadena, J. A., 2005. Cost-benefit analysis of HACCP implementation in the Mexican meat industry. *Food Control*, 16(4), pp.375-381.

Malik, R.E., Cooper, R.A. & Griffith, C.J., 2003. Use of audit tools to evaluate the efficacy of cleaning systems in hospitals. *American Journal of Infection Control*, 31(3), pp.181-187.

Martin, S.A. & Anderson, D.W., 2000. HACCP adoption in the U.S. Food Industry. In Unnevehr, L.J. (Ed.). *The economics of HACCP: costs and benefits* (pp.15-28). Minnesota: Eagan Press.

Mayes, T., 1999. How can the principles of validation and verification be applied to hazard analysis? *Food Control*, 10, pp.277-279.

Ministry of Commerce, Industry and Tourism, Statistical Service of Cyprus, 2005. *Small Medium Sized Enterprises* [online].

Available at: http://www.mcit.gov.cy/mcit/mcit.nsf/dmlsme_gr/dmlsme_gr?OpenDocument

[Accessed 25 November 2005].

Ministry of Health Cyprus, 2005. HACCP inspectional guide [online].

Available at: http://www.moh.gov.cy/moh/moh.nsf/medpub_gr/medpub_gr?OpenDocument

[Accessed 10 November 2005].

Ministry of Health, Cyprus, 2004. *Health practices guide.* Nicosia: Vasiliou Publications.

Ministry of Health, Public Health Services, 1996. *The food (Control and Services) law of 1996* [online]. Available at:

http://www.moh.gov.cy/Moh/mphs/phs.nsf/DMLlegislation1_gr/DMLlegislation1_gr?OpenDocument

[Accessed 12 November 2005].

Montville, R., Chen, Y., & Schaffner, D.W., 2001. Glove barriers to bacterial cross-contamination between hands to food. *Journal of Food Protection,* 64(6), pp.845-849.

Mortimore, S., 2003. ERG notation, p. A-50.

Mortimore, S., 2001. How to make HACCP really work in practice. *Food Control*, 12, pp. 209-215.

Mortimore, S. & Wallace, C., 1998. *HACCP: A practical approach*. 2nd ed. Gaithersburg: Aspen Publishers.

Mortlock, M.P., Peters, A.C. & Grifith, C.J., 2000. A national survey of food hygiene training and qualification levels in the UK food industry. *International Journal of Environmental Health Research,* 10, pp. 111-123.

Mortlock, M.P., Peters, A.C., & Grifith, C.J., 1999. Food hygiene and HACCP in the UK food industry: Practices, perceptions and attitudes. *Journal of Food Protection,* 62(7), 786-792.

Motarjemi, Y. & Mortimore, S., 2005. Industry's need and expectations to meet food safety, 5th International Meeting: Noordwijk Food Safety and HACCP forum 9-10 December 2002. *Food Control,* 16(6), pp.523-529.

Motarjemi, Y. & M. van Schothorst, 1999. HACCP, principles and practice. In Jongeneerl, S. ed. *Teacher's Handbook.* A WHO/ICD Training Manual in Collaboration with FAO. World Health Organization, Geneva, Switzerland.

Motarjemi, Y. & Kaferstein, F., 1999. Food safety, HACCP and the increase in foodborn diseases: a paradox? *Food Control*, 10 pp.325-333.

NAS, 1985. An evaluation of the role of microbiological criteria for foods and food ingredients., Washington, DC: National Academy Press.

NACMCF, 1997. *Hazard analysis and critical control point: principles and application practices.*

Available at: http://vm.cfsan.fda.gov/~comm/nacmcfp.html#execsum

[Accessed 5 November 2007].

NACMCF, 1992. Hazard Analysis and Critical Control Point System. *International Journal of Food Microbiology*, 16, pp.1-23.

NACMCF, 1989. *HACCP principles for food production.* Ad Hoc HACCP working Group, D. A. Corlett, chair. In Pierson and Corlett, HACCP: Principles and Applications. New York: Chapman and Hall.

Nganje, W.E. & Mazzocco, M.A., 2000. Economic efficiency of HACCP in the US red meat industry. In Unnevehr, L.J. ed. *The economics of HACCP: costs and benefits*. Minnesota: Eagan Press, pp.241-266.

Nicolaou, A., 2003. Food companies are shutting down. *Phileleftheros* online. 23 November.

Available at: http://217.27.32.141/main/main.asp?gid=138&issuenum=15830

[Accessed 15 October 2005].

Overbosch, P., Lozano, A.L. & Mould S., 2008. Kraft Foods evaluates ISO 22000 as global standard for ensuring food safety, Special Report, ISO Management systems. Available at: http://www.iso.org/ims.
[Accessed 15 October 2009].

Panisello, P.J. & Quantick, P.C., 2001. Technical barriers to hazard analysis critical control point (HACCP). *Food Control*, 12(3), pp.165-173.

Panisello, P.J., Quantick, P.C. & Knowles, M.J., 1999. Towards the implementation of HACCP: results of a UK regional survey. *Food Control*, 10, pp.87-98.

Pierson, M.D. & Corlett, D.A., 1992. *HACCP: principles and applications*, New York, Van Nostrand Reinhold.

Pillsbury Company, 1973. *Food safety through the hazard analysis and critical control point system*, Minneapolis, MN: Pilsbury.

Ramirez, A. & Fernandez, J. M., 2003. Barriers for the developing and implementation of HACCP plans: results from a Spanish regional survey. *Food Control*, 14(5), pp. 333-337.

Regulation (EC) No 882/2004, 2004. Official Journal of the European Union, No, L165/1, 30.4.2004, pp. 1-59.

Regulation (EC) No 852/2004, 2004. Official Journal of the European Union, No, L226, 25.6.2004, pp. L226/3-7.

Regulation (EC) No 853/2004, 2004. Official Journal of the European Union, No, L139, 25.6.2004, pp. 22-82.

Regulation (EC) No 178/2002, 2002. Official Journal of the European Communities, No, L31/1, 1.2.2002, pp. L31/1-6.

Riswadkar, A.V., 2000. An introduction to HACCP the hazard analysis and critical control point system for food processors. *Professional Safety*, 45(6), pp.33-36.

Roland, R., 2002. *Buttherworth's Law of Food & Drugs*: issue 71. Vol. 1. B1-B158.

Ropkins, K. & Beck, A., 2000. Evaluation of worldwide approaches to the use of HACCP to control food safety. *Trends in Food Science and Technology,* 11, pp.10-21.
Royston, P., 1992. Approximating the Shapiro-Wilk w-test for non-normality. *Statistics and Computing*, 20, pp.11-119.

Selman, C., 2006. *Understanding the causes of foodborne illness. CDC. Environmental Health Specialists Network* [online]. Available at:
http://www.cdc.gov/nceh/ehs/EHSNet/Docs/Understanding_Causes_of_Foodborne_Illness.pdf
[Accessed 6 November 2007].

Semos, A. & Kontogeorgos, A., 2007. HACCP implementation in northern Greece: Food companies' perception of costs and benefits. *British Food Journal*, 109(1), pp.5-19.

Seward, S., 2000. Application of HACCP in the foodservice. *Irish Journal of Agriculture and Food research,* 39(2) pp. 221-227.

Shapiro, S.S. & Wilk, M.B., 1965. An analysis of variance test for normality (complete samples). *Biometrika*, 52(3 and 4), pp.591-611.

Smith, M., Hunedy, O. & Anvarian, A., 2004. *Safer food better business, developing the principles of a HACCP management system to apply in Balti restaurants. Final*

Report. Division of Environmental Health and Risk Management. The University of Birmingham.

Smith, M., Hussain, S. & Millward, J., 2002. Effect of the licensing process on hygiene in retail butchers' premises in the West Midlands, United Kingdom. *Journal of Food Protection*, 65(9), pp.1428-1432.

Soriano, J. M., Rico, H., Molto J.C., & Mañes, J., 2002. Effect of introduction of HACCP on the microbiological quality of some restaurant meals. *Food Control*, 13(4-5), pp.253-261.

Souness, R., 2000. HACCP in Australian food control. *Food Control,* 11(5), pp.353-357.

Sperber, W., 2005. HACCP does not work from Farm to table. *Food Control,* 16(6), pp.511-514.

Sperber, W., 1998. Auditing and verification of food safety and HACCP. *Food Control,* 9(2-3), pp.157-162.

Statistical Service of Cyprus, 2005. *Business Economic Report*, Business Register.

Strohbehn, C.H., Gilmore, S.A. & Sneed, J., 2004. Food safety practices and HACCP implementation: perception of registered dieticians and dietary managers. *Journal American Diet Association,* 104, (11), pp.1692-1699.

Swanson, K. M. & Anderson, J. E., 2000. Industry perspectives and the use of microbial data for hazard analysis and critical control point validation and verification. *Journal of Food Protection,* 63 (6), 815-818.

Swinkels, H., 2008. World's largest veal producer to implement ISO 22000 at all its facilities. Special Report, ISO Management Systems [online].
Available at: http://www.iso.org/ims**.**

[Accessed 6 November 2007].

Taylor, E. & Kane, K., 2004. Reducing the burden of HACCP on SMEs. *Food Control,* 16(10), pp.833-839.

Taylor, E., 2001. *HACCP in small companies: benefit or burden?* Lancashire Postgraduate School of Medicine and Health, University of Lancashire, Preston, UK [online].

Available at: http://www.nutricion.org/publicaciones/pdf/taylor.pdf

[Accessed 7 February 2005].

Towns, R.E., Cullen, R.W., Memken, J.A. & Nnakwe, N.E., 2006. Food safety related refrigeration and freezer practices and attitudes of consumers in Peoria and surrounding counties. *Journal of Food Protection,* 69(7), pp.1640-1645.

Tranchard, S., 2008. *World food giant Danone one of the earliest adopters of ISO 22000, Special Report*, ISO Management systems [online].
Available at: http://www.iso.org/ims**.**
[Accessed 10 January 2009]

Tuominen, P., Hielm, S., Aarnisalo, K., Raaska, L. & Maijala, R., 2003. Trapping the food safety performance of a small or medium sized food company using a risk based model. The HYGRAM system. *Food Control,* 14(8), pp.573-578.

Unnevehr, L.J. & Jensen, H.H., 1999. The economic implications of using HACCP as a food safety regulatory standard. *Food Policy,* 24, pp.625-635.

Untermann, F., 1999. Food safety management and misinterpretation of HACCP. *Food Control*, 10, pp.161-167.

Van Schothorst, M., 2004. *A simple guide to understanding and applying the Hazard Analysis Critical Control Point concept*. 3rd ed. International Life Sciences Institute [online]. Available at: http://www.ilsi.org/Europe/Publications/C2004Simp_GuiEng.pdf

[Accessed 15 March 2007].

Vasiliou, V., 2003a. HACCP: Money under the table. *Phileleftheros Online,* 20 November.

Available at: http://217.27.32.141/main/main.asp?gid=136&id=215481&issuenum=15846 [Accessed 15 November 2005].

Vasiliou, V., 2003b. Embezzlement of government grants by HACCP consultants *Phileleftheros Online*, 18 November.

Available at**:** http://217.27.32.141/main/main.asp?gid=136&id=215110&issuenum=15844

[Accessed 15 November 2005].

Violaris, Y., Bridges, O. & Bridges, J., 2008. Small businesses – big risks: Current status and future direction of HACCP in Cyprus. *Food Control*, 19, pp. 439-448.

Walker, E., Pritchard, C. & Forsythe, S., 2003. Hazard Analysis Critical Control Point and prerequisite programme implementation in small and medium size food businesses. *Food Control*, 14(3), pp.169-174.

Wallace, C. & Williams, T., 2001. Pre-requisites: a help or a hindrance to HACCP? *Food Control*, 12(4), pp.235-240.

Ward, G., 2001. HACCP: heaven or hell for the food industry. *Quality World*, No3, pp.12-15.

WHO, 2004. *5th World Congress: foodborne infections and intoxications*. Berlin, Germany, 7-11 June 2005. WHO: Berlin.

WHO, 1999. *Strategies for implementing HACCP in small and/or less developed businesses*. Report of WHO Consultation. The Hague. Food Safety Programme WHO.

WHO, 1998. *Guidance on regulatory assessment of HACCP*. Report of the joint FAO/WHO Consultation on the Role of the Government Agencies in Assessing HACCP. Geneva. 2-6 June 1998 [online].

Available at: http://www.who.int/foodsafety/fs_management/en/.

[Accessed 18 February 2007].

WHO, 1995. *Hazard Analysis Critical Control Point System: Concept and Application*. Report of a WHO Consultation with the participation of FAO, Geneva, 29-31 May 1995. WHO document WHO/FNU/FOS/95.7

Worsfold, D. & Griffith, C.J., 2003. Widening HACCP implementation in the catering industry. *Food Service Technology*, 3, pp.113-122.

Youn, S. & Sneed, J., 2003. Implementation of HACCP and prerequisite programs in school foodservice. *Journal of the American Dietetic Association*, 103(1), pp. 55-60.

Zorpas, A. & Tzia, N., 2008. The implementation of a new ISO 22000 in the Cyprus Olive Oil Industry. *Risk Analysis VI*.

APPENDICES

Appendix A: Audit Check List

Appendix A1: Audit Check List Form

AUDIT CHECKLIST FORM

Level: ……………..

Enterprise Audit	
Name of the company	
Town	
Telephone, Fax	
Name of the owner	
Type of the company	Group 1: Restaurant ☐, Group 2: Fast food ☐, Group 3: Catering ☐, Group 4: Tavern ☐ , Group 5: Confectionery ☐, Group 6: Butchery ☐, Group 7: Coffee& Restaurant ☐, Group 8: Bakery ☐, Group 9: Small food factory ☐
Personnel (managers, employees, owners)	
Number of employees	
No of previous audits	
Audit Date	
Audit results (number of Yeses): Part A/Part B/Part C/ Part D/Part E	
Total audit result:	
ΜΕΡΟΣ Α: ΥΠΟΔΟΜΗ – ΚΑΤΑΣΚΕΥΗ PART A: Building and Facilities	

	Εξωτερικό Περιβάλλον/ Area around the building	ΝΑΙ/ YES	ΟΧΙ/ NO
1	Απουσία πηγών μόλυνσης έξω από την εγκατάσταση, υγιεινή του περιβάλλοντος χώρου. Is the area around the enterprise clear to prevent contaminations and pest control?		
	Σχεδιασμός εγκατάστασης /Building design		
2	Κατασκευή και διαρρύθμιση των χώρων ανάλογη προς το είδος και το μέγεθος των εργασιών Is the building arrangement according to the business functions?		
3	Διαχωρισμός χώρων αποθήκευσης, παρασκευαστηρίου και διάθεσης. Is there enough space for storage and preparing of the food?		
4	Παρασκευαστήριο: Is the production area separated in: - χώρος προετοιμασίας ωμών τροφίμων ☐ Place for preparation of raw food - χώρος προετοιμασίας λαχανικών ☐ Place for preparation of fresh products and vegetables - χώρος θερμικής επεξεργασίας ☐ Place for cooking and heating - χώρος πλυσίματος σκευών ☐ Place for equipment washing and cleaning - χώρος κρύας κουζίνας ☐ Place for the main kitchen and preparation		
5	Αποκλεισμός εισόδου πελατών στους χώρους παρασκευής Is the traffic within the plant controlled to prevent contamination of the production area from the visitors?		

Δάπεδα / Τοίχοι / Οροφές / Πόρτες / Παράθυρα/ Floors/ walls/ ceilings/doors/ windows		ΝΑΙ/ YES	ΟΧΙ/ NO
6	**Δάπεδα/ Floors:** Υλικά κατασκευής κατάλληλα– Κατάσταση συντήρησης- Δυνατότητα καθαρισμού & αποστράγγισης. Are floors made out of proper material that can be cleaned and dry easily?		
7	**Τοίχοι/ Walls:** Από κατάλληλα υλικά, χρήση στεγανών, μη απορροφητικών και μη τοξικών υλικών που να καθαρίζονται και να απολυμαίνονται εύκολα. Are walls made out of proper non toxic material that can be cleaned easily?		
8	**Οροφές / Ceilings :** Κατασκευή - Κατάσταση συντήρησης που να αποτρέπουν συσσώρευση ρύπων και τη συμπύκνωση υδρατμών. Are ceilings maintained and cleaned easily and there is no concentration of vapour?		
9	**Παράθυρα / Windows :** Εφοδιασμένα με ειδικά πλέγματα προστασίας. Do production area windows to the outside have fine mesh screens?		
10	**Πόρτες/ Doors:** Από λεία και μη απορροφητικά υλικά για να καθαρίζονται εύκολα Are doors made of material that can properly maintained and cleaned?		
Αερισμός / Φωτισμός / Ventilation /Lighting		**ΝΑΙ/ YES**	**ΟΧΙ/ NO**
11	Επάρκεια μηχανικού ή φυσικού Αερισμού Is there physical or technical ventilation?		
12	Επαρκής φυσικός ή τεχνητός φωτισμός με προστατευμένα φωτιστικά μέσα Are there enough overhead lights that they are covered with shields to prevent contamination of products by broken glass in case the lamb burst?		
Αποχέτευση/ Sanitation		**ΝΑΙ/ YES**	**ΟΧΙ/ NO**
13	Αποτελεσματική απομάκρυνση και διάθεση λυμάτων, με υγειονομικούς όρους Effective removal and disposition of the wastes according to the health services.		
14	Υγειονομικά φρεάτια με ανοξείδωτες σχάρες στα δάπεδα Are there sanitary shaft with stainless grills in the floors?		

	Χώροι Υγιεινής – Rest rooms	ΝΑΙ/ YES	ΟΧΙ/ NO
15	Τουαλέτες προσωπικού: αριθμός – καταλληλότητα Is there enough number of rest rooms according to the number of employees?		
16	Υπάρχουν νιπτήρες εξοπλισμένοι με στεγνωτήρες χεριών και σαπούνι? Are the hand- washing facilities furnished with paper or air hand dryers and soap?		
17	Κατάλληλο σύστημα φυσικού ή μηχανικού αερισμού Is there a suitable system of natural or mechanic airing?		
18	Προθάλαμος τουαλετών με νιπτήρες Is there a rest room lobby with hand –washing facilities?		
19	Ιδιαίτερος χώρος αποδυτηρίων (πάνω από 3 εργαζόμενοι) Are there changing rooms (for more than 3 employees)		
20	Επαρκής αριθμός κατάλληλων ερμαρίων Enough number of lockers for the employees?		

ΕΞΟΠΛΙΣΜΟΣ
EQUIPMENT

		ΝΑΙ/ YES	ΟΧΙ/ NO
21	**Έλεγχος ως προς την <u>επάρκεια</u>, την <u>καταλληλότητα</u> των υλικών κατασκευής και την κατάσταση <u>συντήρησης – υγιεινής</u>:** **Is the following equipment designed, or otherwise suitable, for use in the food plant?:**		
	• Ψυγεία • Fridge		
	• Φούρνοι, γκριλ • Oven, Grill		
	• Εξοπλισμός χώρων παρασκευής, σκεύη • Equipment for the food preparation and utensils,		
	• Πάγκοι εργασίας & επιφάνειες κοπής • Work benches & cutting surfaces		
	• Εξοπλισμός διατήρησης των έτοιμων φαγητών (θερμοθάλαμοι, βιτρίνες έκθεσης) • Preservation Equipment for ready foods		
	• Προθήκες – ερμάρια αποθήκευσης σκευών • Sanitary storage		
	• Αρτοθήκες, ερμάρια ξηρής αποθήκευσης τροφίμων • Storage for dry food		
22	• Μπορούν οι επιφάνειες του εξοπλισμού να καθαρίζονται εύκολα? • Can the surface of the equipment be sanitized?		
	Χώροι πλύσης /Spaces of wash	**ΝΑΙ/ YES**	**ΟΧΙ/ NO**

23	Κατάλληλος και επαρκής εξοπλισμός για το πλύσιμο των σκευών, των εργαλείων και του εξοπλισμού με κατάλληλη σήμανση Is there suitable and sufficient equipment for washing utensils with the appropriate labelling?		
24	Νιπτήρες για το πλύσιμο των τροφίμων με κατάλληλη σήμανση Is there suitable and sufficient equipment for food washing with the appropriate labelling?		
25	Νιπτήρας για το πλύσιμο των χεριών με κατάλληλη σήμανση Is there suitable and sufficient equipment for hand washing with the appropriate labelling?		
	Νερό – Water		
26	Υπάρχουν βαλβίδες για αποτροπή της επιστροφής νερού για αποφυγή επιμόλυνσης? Do your facilities have back flow and vacuum breaker valves to prevent contaminate your water supply?		
27	Το νερό που χρησιμοποιείται πρέπει να έχει τα χαρακτηριστικά του πόσιμου νερού σύμφωνα με την Κείμενη Νομοθεσία Is the water used in your enterprise from an approved source and according to legislation?		

ΜΕΡΟΣ Β: Καθαρισμός – Απολύμανση
PART B: Cleaning – Disinfection

1	Εφαρμογή κατάλληλου προγράμματος καθαρισμού και απολύμανσης Is there an application of an established cleaning procedure for the following: • Στις αποθήκες πρώτων υλών και βοηθητικών υλών • Storages		
	• Στους χώρους προετοιμασίας-παρασκευής • Production area		
	• Στους χώρους υγιεινής & στους κοινόχρηστους χώρους της εγκατάστασης • Rest rooms		
2	Υλικά καθαρισμού εγκεκριμένα, που διατηρούνται σε ασφαλές σημείο Are all sanitation chemicals used in the plant approved according to legislation and stored in a safe place?		
3	Είναι όλος ο εξοπλισμός που έρχεται σε επαφή με τα τρόφιμα καθαρός και στη συχνότητα που πρέπει? Is all equipment that comes in contact with food cleaned and sanitize as often as necessary?		
4	Υπάρχουν υπολείμματα τροφίμων στον εξοπλισμό? Is there a build-up of food or other material on the equipment?		

5	Υπάρχουν υπολείμματα καθαριστικών στον εξοπλισμό? Is there any build-up or seepage of cleaning solvents or lubricants on the equipment, which can contaminate food?		
	Διαχείριση Απορριμμάτων / Garbage	**NAI/ YES**	**OXI/ NO**
6	Επάρκεια κατάλληλων δοχείων απορριμμάτων στις κατάλληλες θέσεις. Is the garbage kept covered and in the right place?		
7	Τακτική απομάκρυνση απορριμμάτων και χρήση κατάλληλων κάδων. Is garbage quickly removed and dumped in appropriate bins?		
	Υγιεινή Προσωπικού και Πρακτικές Χειρισμού των τροφίμων/ Personnel – Worker Health and Hygiene	**NAI/ YES**	**OXI/ NO**
8	Τήρηση κανόνων ατομικής υγιεινής, κατάλληλος και καθαρός ιματισμός, δεν φορούν κοσμήματα Are the employees wearing jewellery, rings, watches, fingernail polish or bandages?		
9	Ορθοί χειρισμοί από το προσωπικό κατά την επεξεργασία και διάθεση των τροφίμων In handling food products, do the employees wear the proper hair covering, beard covering, disposable gloves and clean uniforms?		
10	Το προσωπικό πλένει τα χέρια του και αλλάζει γάντια όποτε απαιτείται Do the employees wash and sanitize their hands after each visit to the toilet? Do they changed gloves when is necessary?		
11	Δεν καπνίζει, τρώει ή φυλάσσει προσωπικά αντικείμενα στο χώρο εργασίας Do employees eat, drink, and use tobacco products only in designated areas, and not in the production area or warehouse?		
12	Απαγόρευση χειρισμού τροφίμων από ασθενείς εργαζόμενους Do the employees have any illnesses, infections or injuries (i.e, boils, cuts) that can contaminate food in the production area?		
13	Πρόσθετα μέτρα ελέγχου της υγείας του προσωπικού Do the employees maintain clean personal habits?		
	Καταπολέμηση Τρωκτικών και Εντόμων/ Pest Control	**NAI/ YES**	**OXI/ NO**
14	Χρήση προληπτικών μέτρων (σίτες, αεροκουρτίνες, άλλοι προστατευτικοί μηχανισμοί) Do you have professional pest control services?		
15	Εφαρμογή επαρκούς συστήματος απεντομώσεων- μυοκτονιών. Do you have enough bait stations?		
16	Χρήση εγκεκριμένων σκευασμάτων. Do you have documentation on what chemicals are been used? Are they approved according to legislation?		
17	Είναι διαθέσιμα τα αρχεία του συστήματος καταπολέμησης τρωκτικών? Are the pest control logs and the documentation readily available?		
18	Είναι καλά αποθηκευμένα τα σκευάσματα? Are pesticides or application equipment stores safely?		

ΜΕΡΟΣ Γ: ΔΙΑΔΙΚΑΣΙΕΣ – ΔΡΑΣΤΗΡΙΟΤΗΤΕΣ
PART C: Production and Process Control

Προστασία της ασφάλειας των τροφίμων/ Food Safety		ΝΑΙ/ YES	ΟΧΙ/ NO
	Προμήθεια / παραλαβή πρώτων και βοηθητικών υλών **Incoming products**		
1	Έλεγχος κατά την παραλαβή των πρώτων και βοηθητικών υλών ώστε να πληρούν τις απαιτήσεις της νομοθεσίας (ασφαλείς, σωστή επισήμανση, κατάλληλη θερμοκρασία) Are all incoming products inspected for damage or contamination so that they can be rejected?		
2	Ἑλεγχος των συνθηκών μεταφοράς κατά την παραλαβή Are incoming vehicles inspected?		
	Αποθήκευση – Θερμοκρασίες **Storage – Temperature**		
3	Υγιεινή και κατάλληλη τοποθέτηση στους χώρους ξηρής αποθήκευσης Are products stored on a first-in first out basis to reduce the possibility of contamination through spoilage?		
4	Τα προϊόντα μη συμμόρφωσης είναι σε ξεχωριστό χώρο με κατάλληλη σήμανση? Are all products spoiled by damage, insects, rodents or other causes stored in a designated “quarantine area” to prevent their contact with safe products?		
5	Στους αποθηκευτικούς χώρους δεν υπάρχουν αλλοιωμένα προϊόντα ή προϊόντα με ληγμένη ημερομηνία συντήρησης Are all incoming products dated to ensure a proper rotation of stocks and for internal tracking purposes?		
6	Ενδείξεις θερμοκρασίας στα ψυγεία ή / και τους θερμοθαλάμους Are there indication of temperature in the refrigerators and freezers?		
7	Θερμοκρασία τροφίμων που διατηρούνται υπό ψύξη <5^{o}C Is the temperature of the food in refrigerator storage <5^{o}C		
8	Θερμοκρασία τροφίμων που διατηρούνται υπό κατάψυξη στους –18^{o}C Is the temperature of the food in fridge storage –18^{o}C		
9	Κατάλληλες συνθήκες αποθήκευσης των υλικών συσκευασίας Are non food materials stored in a safe manner?		

	Επεξεργασία – παραγωγή / Processing - production	ΝΑΙ/ YES	ΟΧΙ/ NO
10	Η επιχείρηση μεριμνά για την αποφυγή διασταυρούμενης επιμόλυνσης που μπορεί να προκληθεί: The enterprise sees for the evasion of a cross contamination that can be caused: • Από τον μη σαφή διαχωρισμό των εργασιών • From the separation of production areas		
	• Από την επεξεργασία ωμών τροφίμων • From the treatment of raw food		
	• Από ακάθαρτα σκεύη και εργαλεία • From the product debris that is not removed properly		
	• Από τη διατήρηση ωμών τροφίμων μαζί με έτοιμα για κατανάλωση τρόφιμα, τα οποία διατηρούνται ακάλυπτα σε ψυγεία ή καταψύκτες • From the joint maintenance of raw food ad ready for consumption food		
	• Από το προσωπικό • From the personnel •		
11	Η απόψυξη των τροφίμων γίνεται υπό ψύξη ή κάτω από τρεχούμενο νερό Is the defrosting of food attained by refrigerated storage?		
	Έκθεση προς πώληση /Product Display		
12	Διατήρηση των θερμοθαλάμων σε θερμοκρασία ≥ 60°C Is the maintenance of the thermo compartments attained in temperature ≥ 60°C?		
13	Οι προθήκες έκθεσης των τροφίμων έχουν την κατάλληλη θερμοκρασία & κατασκευή (προστασία από επιμολύνσεις) The showcases have the suitable temperature?		
14	Ασφαλής τρόπος σερβιρίσματος (λαβίδες, εργαλεία) Is there a safe way of serving the products (pincers, equipments)?		

Μέρος Δ: Διενεργηθέντες Έλεγχοι
PART D: Performed Evaluations

	Μέρος Δ: Διενεργηθέντες Έλεγχοι PART D: Performed Evaluations	NAI/ YES	OXI/ NO
1	Are an organoleptic / microbiological/ chemical evaluations performed on: • Cleaning and sanitizing equipment		
2	• Personnel (handling operations)		
3	• Products		
4	Are an microbiological/ chemical evaluations performed on: • Water		
5	• Incoming products		

Σύστημα HACCP

	Σύστημα HACCP	NAI/ YES	OXI/ NO
1	Έχει εγκατασταθεί στην επιχείρηση σύστημα HACCP; Does the enterprise have the HACCP system?		
2	Εφαρμόζεται το σύστημα HACCP; Is the system implemented? If the system is implemented proceed to PART E audit form		

PART E: HACCP SYSTEM DOCUMENTATION		
REQUIREMENTS	**YES**	**NO**
1. FOOD SAFETY POLICY		
▪ Does a policy for the safety of foods exist and has it been approved by the Administration?		
▪ Does it include commitment for:		
(a) recognition, evaluation and inspection of the hazards related with food safety?		
(b) satisfaction of customers' requirements regarding food safety?		
(c) Satisfaction of the food safety requirements of the legislation and of the relevant authorities?		
2. HACCP TEAM		
▪ Has a HACCP team been constituted and is it considered sufficient?		
▪ Has the coordinator and assistant coordinator of the HACCP team been appointed?		
▪ What are the capabilities and experiences of the team? Does the team considered to be qualified for this purpose?		
▪ Is there any external assistance for support of knowledge and capabilities? If yes give details (name, qualifications, etc.)		
3. PRODUCT DESCRIPTION		
▪ Is the description / specifications for each product prepared?		
▪ Ingredients		
▪ Packaging (external / internal)		
▪ methods of maintenance / storage conditions		
▪ conditions of distribution		
▪ Has the intended aim of use of the product been determined? YES / NO		
▪ Consumers (general, specific)		
▪ Susceptive population (elderly, children, patients, allergic)		
▪ Preparation methods		
▪ Storage conditions		

▪ Usage directions		
▪ Production / expiration date		
▪ Ingredients		
▪ Any compulsory and/or optional sealing		
4. FLOW DIAGRAM		
▪ Is a flow diagram for each product prepared?		
▪ If not, specify for which products.		
▪ Is the flow diagram complete or incomplete?		
▪ Are all the functions of the unit included?		
▪ Are all the main information confirmed?		
▪ Is the flow diagram confirmed? If yes, when did the confirmation took place?		
PRINCIPAL 1: CONDUCT A HAZARD ANALYSIS		
▪ Did all biological, chemical or natural hazards been verified at each stage? (Mention cases where hazards have not been identified as they should)		
▪ Is the recognition of the hazards done with systematic methodology?		
▪ Are the hazards and their importance estimated?		
▪ Are the inspection measures for the hazards developed and applied?		
▪ Are these preventing inspection measures sufficient?		
PRINCIPAL 2: CRITICAL CONTROL POINTS (CCP)		
▪ Are all the CCP for every major hazard ascertained and are they registered to the hazard control table?		
▪ Was the method used for the identification of the CCP systematic?		
▪ Was its use sufficient?		
▪ Check if:		
(a) The usage of the method is visible through specific printed matter		

and data (b) If there is a hazard for the safety of a food that is not checked through the CCP		
▪ Are there many CCP that are not actually CCP that complicate the functionality of the system?		
▪ Are all the CCP necessary for inspecting a hazard? YES / NO		
▪ Are all the working instructions and the inspection parameters for each CCP complete? Record for which critical points the inspection parameters are not fully determined.		
PRINCIPAL 3: CRITICAL LIMITS		
▪ Have critical limits been established for every critical inspection parameter?		
▪ If not, record for which parameter the critical limit is no set down and why.		
▪ Is the relationship between hazard and critical limit correct?		
▪ In which way are the limits specified?		
(a) From experimental evidence		
(b) From published results		
(c) From bibliography		
(d) From legislation		
▪ Record cases of critical limits that have been set down and can not be measured with the existing observation methods.		
PRINCIPAL 4: MONITORING PROCEDURES FOR EVERY CCP		
▪ Do the monitoring procedures identify what, when, how, where and who?		
▪ Is the monitoring procedures frequency sufficient for providing high security standards? Is the procedure under control?		
▪ Are monitoring data kept and is there a review from authorized personnel?		
▪ Are they recorded properly?		
▪ Are they signed by the person in charge for the observation?		
▪ Have monitoring procedures been established for every Critical Control Point?		

▪ Do they have the signature of the person in charge for the evaluation?		
▪ Are there any monitoring form samples in the manual?		
PRINCIPAL 5: CORRECTIVE ACTIONS FOR EACH CCP		
▪ Are corrective actions created for each Critical Control Point?		
▪ Are there people in charge for reaching each corrective actions?		
▪ Do these corrective actions confirm that the critical control points are under inspection?		
▪ Do these corrective actions cover the product, the procedure, and do they guaranty repetition?		
▪ Is there a complete record of the corrective actions that take place?		
PRINCIPAL 6: VERIFICATION PROCEDURES		
▪ Are verification procedures used for showing the effectiveness of the HACCP program?		
▪ Have the critical limits been validated?		
▪ Does this verification show that the CCP are under examination?		
▪ Does the verification process confirm that the HACCP program is efficient?		
PRINCIPAL 7: DATA/ RECORD KEEPING		
▪ Is there established documentation for all monitoring procedures?		
▪ How is it ascertained that all critical limits remain as specified?		
▪ Is there established documentation for correction measures?		
▪ Is there documentation for all HACCP confirmation activities?		

ARCHIVE OF HACCP SYSTEM		
▪ Is there established documentation (handbook) for quality?		
▪ Quality policy?		
▪ Procedures, documentation with operation instructions and verified specifications?		
▪ Are all the preceding under control and safe keep?		
▪ Is a specific and sufficient duration of keeping the archive specified?		
▪ Investigate whether:		
(a) A specific and sufficient duration of keeping the system's archive is specified.		
(b) This is considered to be satisfactory based on the life span of the products / legal obligations of the company / clients' requirements.		

▪ Is it easy to retrieve?		
▪ Investigate whether:		
(a) The person in charge for keeping the archive and the place for keeping it is clearly specified.		
(b) They are in place.		
(c) They are kept in a safe manner.		
TEST OF A NON CONFORMITY PRODUCT		
▪ Are there sufficient documented detection and testing procedures of the non conformity products?		
▪ Is the non conformity product ensured not to be used / consumed by accident?		
NOTIFICATION AND TRACE BACK		
▪ Is there sufficient and documented procedure for notification / trace of a product?		
▪ Check if the following information is given:		
(a) List of authorities in charge and clients that have to be notified.		
(b) Way of notification of clients and completeness of the given information.		
(c) Mechanism of collecting traced quantity.		
(d) Way of calculating any remaining quantity in the market.		
PROCEDURES OF GOOD MANUFACTURE PRACTICE		
▪ A policy for good manufacture practice has been defined.		
▪ Is there a system for an internal test of good manufacture practice?		
▪ Are there any corrective actions taking place in case of non conformity with the procedures of good manufacture practice?		
▪ Has the procedure of good manufacture practice been tested in depth?		
CLEANING PROCEDURES		
▪ Are the cleaning procedures generated?		
▪ Is there any verification / confirmation system for the effectiveness of the cleaning measures applied?		
▪ What kinds of measures are documented?		
PEST CONTROL		
▪ Are the measures for pest control in effect?		

▪ Are there any verification / confirmation systems for the effectiveness of the above measures in effect?		
▪ Do the procedures include correction actions?		
TRAINING		
▪ Is there any evidence of training of the personnel?		
▪ Is there any re-appraisal of the training needs in a continuous base?		
▪ Is there a plan of ascertaining the training needs?		
INSPECTION OF EQUIPMENT AND CALIBRATION		
▪ Is there a standard procedure for inspecting and calibrating all the used (observation actions / accreditation / verification) equipment		
▪ Is the equipment tested / calibrated?		
▪ Is the testing frequency satisfactory?		
▪ Is the calibration taking place against known and valid standards?		
▪ Is there a full calibration archive for the equipment?		

Στοιχεία Επιθεωρητών/ Auditors

Σχόλια / Συμπεράσματα / Συστάσεις General Comments

	Ονοματεπώνυμο / Name	
Ημερομηνία επανελέγχου : Date of the next proposed audit:		

Appendix A2: Validation of Audit Checklist Form

TEST FOR GRA1

Ranks Test

	AUDITOR	N	Mean Rank	Sum of Ranks
GRA1	Auditor 1	19	19,34	367,50
	Auditor 2	19	19,66	373,50
	Total	38		

Statistics(b)

	GRA1
Mann-Whitney U	177,500
Wilcoxon W	367,500
Z	-,088
Asymp. Sig. (2-tailed)	,930
Exact Sig. [2*(1-tailed Sig.)]	,931(a)

a Not corrected for ties.
b Grouping Variable: AUDITOR

TEST FOR GRB1

Ranks

	AUDITOR	N	Mean Rank	Sum of Ranks
GRB1	Auditor 1	19	19,03	361,50
	Auditor 2	19	19,97	379,50
	Total	38		

Test Statistics(b)

	GRB1
Mann-Whitney U	171,500
Wilcoxon W	361,500
Z	-,267
Asymp. Sig. (2-tailed)	,789
Exact Sig. [2*(1-tailed Sig.)]	,795(a)

a Not corrected for ties.
b Grouping Variable: AUDITOR

TEST FOR GRC1

Ranks

	AUDITOR	N	Mean Rank	Sum of Ranks
GRC1	Auditor 1	19	19,61	372,50
	Auditor 2	19	19,39	368,50
	Total	38		

Test Statistics(b)

	GRC1
Mann-Whitney U	178,500
Wilcoxon W	368,500
Z	-,059
Asymp. Sig. (2-tailed)	,953
Exact Sig. [2*(1-tailed Sig.)]	,954(a)

a Not corrected for ties.
b Grouping Variable: AUDITOR

TEST FOR GRD1

Ranks

	AUDITOR	N	Mean Rank	Sum of Ranks
GRD1	Auditor 1	19	18,79	357,00
	Auditor 2	19	20,21	384,00
	Total	38		

Test Statistics(b)

	GRD1
Mann-Whitney U	167,000
Wilcoxon W	357,000
Z	-,432
Asymp. Sig. (2-tailed)	,666
Exact Sig. [2*(1-tailed Sig.)]	,708(a)

TEST FOR GRA2

Ranks Test

	AUDITOR	N	Mean Rank	Sum of Ranks
GRA2	Auditor 1	19	19,89	378,00
	Auditor 2	19	19,11	363,00
	Total	38		

Statistics(b)

	GRA3
Mann-Whitney U	173,000
Wilcoxon W	363,000
Z	-,220
Asymp. Sig. (2-tailed)	,826
Exact Sig. [2*(1-tailed Sig.)]	,840(a)

a Not corrected for ties.
b Grouping Variable: AUDITOR

TEST FOR GRB2

Ranks

	AUDITOR	N	Mean Rank	Sum of Ranks
GRB2	Auditor 1	19	18,89	359,00
	Auditor 2	19	20,11	382,00
	Total	38		

Test Statistics(b)

	GRB3
Mann-Whitney U	169,000
Wilcoxon W	359,000
Z	-,350
Asymp. Sig. (2-tailed)	,726
Exact Sig. [2*(1-tailed Sig.)]	,751(a)

a Not corrected for ties.
b Grouping Variable: AUDITOR

TEST FOR GRC2

Ranks Test

	AUDITOR	N	Mean Rank	Sum of Ranks
GRC2	Auditor 1	19	19,03	361,50
	Auditor 2	19	19,97	379,50
	Total	38		

Statistics(b)

	GRC3
Mann-Whitney U	171,500
Wilcoxon W	361,500
Z	-,267
Asymp. Sig. (2-tailed)	,789
Exact Sig. [2*(1-tailed Sig.)]	,795(a)

a Not corrected for ties.
b Grouping Variable: AUDITOR

TEST FOR GRD2

Ranks

	AUDITOR	N	Mean Rank	Sum of Ranks
GRD2	Auditor 1	19	20,00	380,00
	Auditor 2	19	19,00	361,00
	Total	38		

Test Statistics(b)

	GRD2
Mann-Whitney U	171,000
Wilcoxon W	361,000
Z	-,320
Asymp. Sig. (2-tailed)	,749
Exact Sig. [2*(1-tailed Sig.)]	,795(a)

a Not corrected for ties.
b Grouping Variable: AUDITOR

TEST FOR GRE2

Ranks Test

	AUDITOR	N	Mean Rank	Sum of Ranks
GRE2	Auditor 1	19	18,97	360,50
	Auditor 2	19	20,03	380,50
	Total	38		

Statistics(b)

	GRE2
Mann-Whitney U	170,500
Wilcoxon W	360,500
Z	-,294
Asymp. Sig. (2-tailed)	,769
Exact Sig. [2*(1-tailed Sig.)]	,773(a)

a Not corrected for ties.
b Grouping Variable: AUDITOR

Appendix A3: Statistical Results for Parts A-E of the Audit Check List

Part A: Building and Facilities Audit

Tests of normality for Part A: "Building and Facilities" of the audit checklist

	AUDIT	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	Df	Sig.
AUDIT PARTA	Audit 1	.116	50	.088	.957	50	.070
	Audit 2	.170	50	.001	.915	50	.002
	Audit 3	.151	50	.006	.918	50	.002
	Audit 4	.133	50	.028	.964	50	.129
	Audit 5	.133	50	.028	.964	50	.129

a. Lilliefors Significance Correction

Wilcoxon signed rank test statistics for Part A: "Building and Facilities" of the audit checklist

Test Statistics[b]

	Infrastructure score audit 2 – infrastructure score audit 1
Z	-6.159[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Infrastructure score audit 3 – infrastructure score audit 2
Z	-3.463[a]
Asymp. Sig. (2-tailed)	.001

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Infrastructure score audit 4 – infrastructure score audit 3
Z	-2.060[a]
Asymp. Sig. (2-tailed)	.039

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Infrastructure score audit 5 – infrastructure score audit 4
Z	.000[a]
Asymp. Sig. (2-tailed)	1.000

a. The sum of negative ranks equals the sum of positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks for consecutive audits for Part A: "Building and Facilities" of the audit checklist

Ranks

		N	Mean Rank	Sum of Ranks
Building and facilities score audit 2 - Building and facilities score audit 1	Negative Ranks	0[a]	.00	.00
	Positive Ranks	50[b]	25.50	1275.00
	Ties	0[c]		
	Total	50		

a. Building and facilities score audit 2 < Building and facilities score audit 1

b. Building and facilities score audit 2 > Building and facilities score audit 1

c. Building and facilities score audit 2 = Building and facilities score audit 1

Ranks

		N	Mean Rank	Sum of Ranks
Building and facilities score audit 3 - Building and facilities score audit 2	Negative Ranks	1[a]	3.50	3.50
	Positive Ranks	16[b]	9.34	149.50
	Ties	33[c]		
	Total	50		

a. Building and facilities score audit 3 < Building and facilities score audit 2

b. Building and facilities score audit 3 > Building and facilities score audit 2

c. Building and facilities score audit 3 = Building and facilities score audit 2

Ranks

		N	Mean Rank	Sum of Ranks
Building and facilities score audit 4 - Building and facilities score audit 3	Negative Ranks	0[a]	.00	.00
	Positive Ranks	5[b]	3.00	15.00
	Ties	45[c]		
	Total	50		

a. Building and facilities score audit 4 < Building and facilities score audit 3

b. Building and facilities score audit 4 > Building and facilities score audit 3

c. Building and facilities score audit 4 = Building and facilities score audit 3

Ranks

		N	Mean Rank	Sum of Ranks
Building and facilities score audit 5 - Building and facilities score audit 4	Negative Ranks	0[a]	.00	.00
	Positive Ranks	0[b]	.00	.00
	Ties	50[c]		
	Total	50		

a. Building and facilities score audit 5 < Building and facilities score audit 4

b. Building and facilities score audit 5 > Building and facilities score audit 4

c. Building and facilities score audit 5 = Building and facilities score audit 4

Part B: Cleaning and Disinfection

Test of normality for Part B: "Cleaning and Disinfection" of the audit checklist

	AUDITS	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
AUDIT PARTB	Audit 1	.162	50	.002	.924	50	.003
	Audit 2	.170	50	.001	.886	50	.000
	Audit 3	.252	50	.000	.810	50	.000
	Audit 4	.249	50	.000	.881	50	.000
	Audit 5	.142	50	.013	.912	50	.001

a. Lilliefors Significance Correction

Wilcoxon signed rank test statistics for Part B: "Cleaning and Disinfection" of the Audit Checklist

Test Statistics[b]

	Cleaning score audit 2 – Cleaning score audit 1
Z	-5.979[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Cleaning score audit 3 – Cleaning score audit 2
Z	-3.653[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Cleaning score audit 4 – Cleaning score audit 3
Z	-3.336[a]
Asymp. Sig. (2-tailed)	.001

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Cleaning score audit 5 – Cleaning score audit 4
Z	-4.575[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Cleaning score audit 5 – Cleaning score audit 1
Z	-5.371[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks for consecutive audits for Part B: "Cleaning and Disinfection" of the audit checklist

Ranks

		N	Mean Rank	Sum of Ranks
Cleaning score audit 2 - Cleaning score audit 1	Negative Ranks	0[a]	.00	.00
	Positive Ranks	47[b]	24.00	1128.00
	Ties	3[c]		
	Total	50		

a. Cleaning score audit 2 < Cleaning score audit 1

b. Cleaning score audit 2 > Cleaning score audit 1

c. Cleaning score audit 2 = Cleaning score audit 1

Ranks

		N	Mean Rank	Sum of Ranks
Cleaning score audit 3 - Cleaning score audit 2	Negative Ranks	0[a]	.00	.00
	Positive Ranks	17[b]	9.00	153.00
	Ties	33[c]		
	Total	50		

a. Cleaning score audit 3 < Cleaning score audit 2

b. Cleaning score audit 3 > Cleaning score audit 2

c. Cleaning score audit 3 = Cleaning score audit 2

Ranks

		N	Mean Rank	Sum of Ranks
Cleaning score audit 4 - Cleaning score audit 3	Negative Ranks	25[a]	16.66	416.50
	Positive Ranks	6[b]	13.25	79.50
	Ties	19[c]		
	Total	50		

a. Cleaning score audit 4 < Cleaning score audit 3

b. Cleaning score audit 4 > Cleaning score audit 3

c. Cleaning score audit 4 = Cleaning score audit 3

Ranks

		N	Mean Rank	Sum of Ranks
Cleaning score audit 5 - Cleaning score audit 4	Negative Ranks	29[a]	15.64	453.50
	Positive Ranks	1[b]	11.50	11.50
	Ties	20[c]		
	Total	50		

a Cleaning score audit 5 < Cleaning score audit 4

b. Cleaning score audit 5 > Cleaning score audit 4

c. Cleaning score audit 5 = Cleaning score audit 4

Ranks

		N	Mean Rank	Sum of Ranks
Cleaning score audit 5 - Cleaning score audit 1	Negative Ranks	4[a]	15.64	453.50
	Positive Ranks	45[b]	11.50	11.50
	Ties	1[c]		
	Total	50		

a Cleaning score audit 5 < Cleaning score audit 1

b. Cleaning score audit 5 > Cleaning score audit 1

c. Cleaning score audit 5 = Cleaning score audit 1

Part C: Production and Process Control

Test of normality for Part C: "Production and Process Control" of the audit checklist

	AUDITS	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
AUDPARTC	Audit 1	.127	50	.043	.980	50	.551
	Audit2	.181	50	.000	.958	50	.074
	Audit 3	.131	50	.031	.948	50	.027
	Audit 4	.139	50	.016	.926	50	.004
	Audit 5	.141	50	.015	.953	50	.044

a. Lilliefors Significance Correction

Wilcoxon signed rank test statistics for Part C: "Production and Process Control" of the audit checklist

Test Statistics[b]

	Process control audit score 2 - Process control score audit 1
Z	-5.249[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Process control score audit 3 - Process control audit 2
Z	-3.942[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Process control score audit 4 - Process control score audit 3
Z	-3.846[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Process control score audit 5 - Process control score audit 4
Z	-5.480[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Process control score audit 5 - Process control score audit 1
Z	-2.895[a]
Asymp. Sig. (2-tailed)	.004

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks for consecutive audits for Part C: "Production and Process Control" of the audit checklist

Ranks

		N	Mean Rank	Sum of Ranks
Process control score audit 2 - Process control score audit 1	Negative Ranks	1[a]	6.00	6.00
	Positive Ranks	35[b]	18.86	660.00
	Ties	14[c]		
	Total	50		

a. Process control score audit 2 < Process control score audit 1

b. Process control score audit 2 > Process control score audit 1

c. Process control score audit 2 = Process control score audit 1

Ranks

		N	Mean Rank	Sum of Ranks
Process control score audit 3 - Process control score audit 2	Negative Ranks	1[a]	22.50	22.50
	Positive Ranks	25[b]	13.14	328.50
	Ties	24[c]		
	Total	50		

a. Process control score audit 3 < Process control score audit 2

b. Process control score audit 3 > Process control score audit 2

c. Process control score audit 3 = Process control score audit 2

Ranks

		N	Mean Rank	Sum of Ranks
Process control score audit 4 - Process control score audit 3	Negative Ranks	0[a]	.00	.00
	Positive Ranks	19[b]	10.00	190.00
	Ties	31[c]		
	Total	50		

a. Process control score audit 4 < Process control score audit 3

b. Process control score audit 4 > Process control score audit 3

c. Process control score audit 4 = Process control score audit 3

Ranks

		N	Mean Rank	Sum of Ranks
Process control score audit 5 - Process control score audit 4	Negative Ranks	39[a]	20.00	780.00
	Positive Ranks	0[b]	.00	.00
	Ties	11[c]		
	Total	50		

a. Process control score audit 5 < Process control score audit 4

b. Process control score audit 5 > Process control score audit 4

c. Process control score audit 5 = Process control score audit 4

Ranks

		N	Mean Rank	Sum of Ranks
Process control score audit 5 - Process control score audit 1	Negative Ranks	12[a]	20.00	780.00
	Positive Ranks	27[b]	.00	.00
	Ties	11[c]		
	Total	50		

a. Process control score audit 5 < Process control score audit 1

b. Process control score audit 5 > Process control score audit 1

c. Process control score audit 5 = Process control score audit 1

Part D: Performance Evaluation of Laboratory Analyses

Test of normality for Part D: "Performance Evaluations of Laboratory Analyses" of the audit checklist

	AUDITS	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
AUDPARTD	Audit 1	.234	50	.000	.826	50	.000
	Audit2	.264	50	.000	.864	50	.000
	Audit 3	.411	50	.000	.608	50	.000
	Audit 4	.535	50	.000	.303	50	.000
	Audit 5	.535	50	.000	.303	50	.000

a. Lilliefors Significance Correction

Wilcoxon signed rank test statistics for Part D: "Performance Evaluations of Laboratory Analyses" of the audit checklist

Test Statistics[b]

	Laboratory analysis score audit 2 - Laboratory analysis score audit 1
Z	-3.626[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Laboratory analysis score audit 3 - Laboratory analysis score audit 2
Z	-6.140[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Laboratory analysis score audit 4 - Laboratory analysis score audit 3
Z	-3.742[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	Laboratory analysis score audit 5 - Laboratory analysis score audit 4
Z	.000[a]
Asymp. Sig. (2-tailed)	1.000

a. The sum of negative ranks equals the sum of positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks for Consecutive Audits for Part D: "Performance Evaluations of Laboratory Analyses" of the Audit Checklist

Ranks

		N	Mean Rank	Sum of Ranks
Laboratory analysis score audit 2 - Laboratory analysis score audit 1	Negative Ranks	0[a]	.00	.00
	Positive Ranks	15[b]	8.00	120.00
	Ties	35[c]		
	Total	50		

a. Laboratory analysis score audit 2 < Laboratory analysis score audit 1
b. Laboratory analysis score audit 2 > Laboratory analysis score audit 1
c. Laboratory analysis score audit 2 = Laboratory analysis score audit 1

Ranks

		N	Mean Rank	Sum of Ranks
Laboratory analysis score audit 3 - Laboratory analysis score audit 2	Negative Ranks	0[a]	.00	.00
	Positive Ranks	48[b]	24.50	1176.00
	Ties	2[c]		
	Total	50		

a. Laboratory analysis score audit 3 < Laboratory analysis score audit 2
b. Laboratory analysis score audit 3 > Laboratory analysis score audit 2
c. Laboratory analysis score audit s3 = Laboratory analysis score audit 2

Ranks

		N	Mean Rank	Sum of Ranks
Laboratory analysis score audit 4 - Laboratory analysis score audit 3	Negative Ranks	0[a]	.00	.00
	Positive Ranks	14[b]	7.50	105.00
	Ties	36[c]		
	Total	50		

a. Laboratory analysis score audit 4 < Laboratory analysis score audit 3
b. Laboratory analysis score audit 4 > Laboratory analysis score audit 3
c. Laboratory analysis score audit 4 = Laboratory analysis score audit 3

Ranks

		N	Mean Rank	Sum of Ranks
Laboratory analysis score audit 5 - Laboratory analysis score audit 4	Negative Ranks	0[a]	.00	.00
	Positive Ranks	0[b]	.00	.00
	Ties	50[c]		
	Total	50		

a. Laboratory analysis score audit 5 < Laboratory analysis score audit 4
b. Laboratory analysis score audit 5 > Laboratory analysis score audit 4
c. Laboratory analysis score audit 5 = Laboratory analysis score audit 4

Part E: HACCP System Documentation

Test of Normality for Part E: "HACCP System Documentation" of the audit checklist

	AUDIT	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
HACCPDOC	Audit 3	.119	50	.075	.937	50	.010
	Audit 4	.098	50	.200[*]	.968	50	.186
	Audit 5	.138	50	.019	.965	50	.139

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

Wilcoxon signed rank test statistics for Part E: "HACCP System Documentation" of the audit checklist

Test Statistics[b]

	HACCP documentation score audit 4 - HACCP documentation score audit 3
Z	-4.026[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Test Statistics[b]

	HACCP documentation score audit 5 - HACCP documentation score audit 4
Z	-6.084[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks for consecutive audits for Part E: "HACCP System Documentation" of the audit checklist

Ranks

		N	Mean Rank	Sum of Ranks
HACCP documentation score audit 4 - HACCP documentation score audit 3	Negative Ranks	0[a]	.00	.00
	Positive Ranks	21[b]	11.00	231.00
	Ties	29[c]		
	Total	50		

a. HACCP documentation score audit 4 < HACCP documentation score audit 3

b. HACCP documentation score audit 4 > HACCP documentation score audit 3

c. HACCP documentation score audit 4 = HACCP documentation score audit 3

Ranks

		N	Mean Rank	Sum of Ranks
HACCP documentation score audit 5 - HACCP documentation score audit 4	Negative Ranks	48[a]	25.50	1224.00
	Positive Ranks	1[b]	1.00	1.00
	Ties	1[c]		
	Total	50		

a. HACCP documentation score audit 5 < HACCP documentation score audit 4

b. HACCP documentation score audit 5 > HACCP documentation score audit 4

c. HACCP documentation score audit 5 = HACCP documentation score audit 4

Appendix B: Environmental and Food Sampling

Appendix B1: Surface swab test analysis

Sample of the results of surface swab test analysis

cp. FOODLAB ltd
Χημείο Νερού – Ποτών - Τροφίμων
Λυμάτων - Περιβάλλοντος

Λεωφ. Τσερίου, 2040 Στρόβολος
Τ.Κ. 28729, 2082 Λευκωσία - Κύπρος
Τηλ. : +(357) 22 45 68 60, 1, 2, 3
Κιν. : +(357) 99 42 68 78
Fax. : +(357) 22 32 15 17

ΕΚΘΕΣΗ ΑΠΟΤΕΛΕΣΜΑΤΩΝ

Όνομα : Αρτοποιϊα ΣΤΕ-ΜΑ
: (Δρόμος Τροόδους, Αστρομερίτη)
Αρ. Δείγματος : 33552-53
Δειγματολήπτης : cp FoodLab Ltd
Χαρακτηριστικά Δείγματος : Swabs, θερμοκρασία (15°C) όπως φαίνεται πιο κάτω
Ημερ. Παραλαβής : 25/04/06
Ημερ. Ανάλυσης : 26-29/04/06
Ημερ. Έκδοσης Αποτελεσμάτων : 01/05/06

Αποτελέσματα

Δείγμα Swabs επιφανειών	Ολικός αριθμός Βακτηριδιών $/64cm^2$
33552, Πάγκος No.1	588
33553, Πάγκος No.2	760

Σημ:

1. Τα αποτελέσματα αφορούν μόνο τα δείγματα που έχουν εξεταστεί.
2. Ικανοποιητικά αποτελέσματα.

Χαρά Παπαστεφάνου
Διευθύντρια

Για το cp FoodLab Ltd

Τέλος Εκθεσης Σελ. 1/1

Η παρούσα έκθεση έχει επιστημονικό χαρακτήρα και δεν μπορεί να χρησιμοποιηθεί για διαφημιστικούς ή άλλους παρόμοιους σκοπούς χωρίς την γραπτή άδεια του Εργαστηρίου
Το cp FoodLab είναι ανεξάρτητο ιδιωτικό εργαστήριο
E-mail: foodlab@cytanet.com.cy

Surface swab tests

Test Statistics[a]

	Test2:Test1
Mann-Whitney U	578.000
Wilcoxon W	1853.000
Z	-4.644
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: SURFACETEST12

Test Statistics[a]

	Test3:Test2
Mann-Whitney U	1114.500
Wilcoxon W	2389.500
Z	-.936
Asymp. Sig. (2-tailed)	.349

a. Grouping Variable: SURFACETEST23

Test Statistics[a]

	Test4:Test3
Mann-Whitney U	863.000
Wilcoxon W	2138.000
Z	-2.676
Asymp. Sig. (2-tailed)	.007

a. Grouping Variable: SURFACETEST34

Test Statistics[a]

	Test5:Test4
Mann-Whitney U	1165.000
Wilcoxon W	2440.000
Z	-.591
Asymp. Sig. (2-tailed)	.554

a. Grouping Variable: SURFACETEST45

Statistical analysis of the surface swab test by activity of enterprises

Level of bacteria on the first surface swab test

	Restaurants	Fast food	Bakeries	Butcheries
Minimum	2.72	3.00	2.09	3.26
Median	3.18	3.26	2.90	3.70
Mean	3.17	3.31	2.86	3.83
Maximum	3.70	3.70	3.26	4.48
Stand.deviation	0.18	0.29	0.33	0.38

Level of bacteria on the second surface swab test

	Restaurants	Fast food	Bakeries	Butcheries
Minimum	2.08	2.60	0.90	2.88
Median	2.81	2.88	2.48	3.48
Mean	2.78	2.96	2.33	3.44
Maximum	3.48	3.54	2.88	4.00
Stand.deviation	0.26	0.36	0.62	0.33

Level of bacteria on the third surface swab test

	Restaurants	Fast food	Bakeries	Butcheries
Minimum	2.11	2.70	1.48	2.86
Median	2.67	2.86	2.18	3.18
Mean	2.70	2.86	2.26	3.24
Maximum	3.00	3.11	2.86	4.00
Stand.deviation	0.19	0.14	0.48	0.37

Level of bacteria on the fourth surface swab test

	Restaurants	Fast food	Bakeries	Butcheries
Minimum	2.40	2.74	1.70	3.00
Median	2.88	3.00	2.54	3.25
Mean	2.86	2.96	2.51	3.45
Maximum	3.18	3.18	3.00	5.00
Stand.deviation	0.17	0.18	0.39	0.65

Level of bacteria on the fifth surface swab test

	Restaurants	Fast food	Bakeries	Butcheries
Minimum	2.54	2.88	2.08	3.00
Median	2.88	3.00	2.70	3.54
Mean	2.85	3.07	2.68	3.62
Maximum	3.30	3.40	3.00	5.00
Stand.deviation	0.18	0.21	0.28	0.61

Appendix B2: Hand swab test analysis

<u>Sample of the results of hands swab test analysis</u>

Foodlab
Tel: 22 ... Fax: 22720747

LABORATORY REPORT/

COMPANY/ΕΤΑΙΡΕΙΑ: MARCOS NICOLAOU

Date Sampling/ Ημερ. Δειγματοληψίας:	18/04/06	Date sample analysed/ Ημερ. Ανάλυσης:	19/04/06
Date sample received/ Ημερ. Παραλαβής Δείγματος:	18/04/06	Date analysis completed/ Ημερ. Ολοκλήρωσης Ανάλυσης:	22/04/06

RESULTS / ΑΠΟΤΕΛΕΣΜΑΤΑ

Lab no	Sample description/ Περιγραφή δείγματος	Sample Code/ Σήμανση δείγματος	Sample location/ Χώρος δειγματολ.	TVC/ Ολικός αριθμός	Coliforms/ Κολοβακτηρίδια	Staph
1790	Χεριμα π αραλαβης			$5*10^6$		
1791	Χεριμα Ψυγειο			$5*10^5$		
1792	Χοιρινο Παραγωγη			$100*10^6$		
1793	Χοιρινο επεξεργασια			$1*10^6$		
1794	Βοδινο			$50*10^4$		
1795	Αρνι			$30*10^3$		
1796	Παγκος μ ετα πλυσιμο			$1*10^3$		
1797	Χερια σφαγειο			$10*10^3$		
1798	Παγκος παραγωγης			$10*10^2$		
1799	Κοκκινο κιβωτιο			$3*10^3$		
1800	Τοιχοι παραγωγης			$5*10^1$		
1801	Νερο				<1	
1802	Νερο από μηχανη				<1	
1803	Επιφανεια ψυγειου			$1*10^3$		

Signature/ Υπογραφή:

A.Ioannou BSc Food Science

Date/ Ημερομηνία: 24/04/06

Hand swab tests

Test Statistics[a]

	Test1:Test2
Mann-Whitney U	742.000
Wilcoxon W	2017.000
Z	-3.511
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: HANDSTEST

Test Statistics[a]

	Test2:Test3
Mann-Whitney U	894.500
Wilcoxon W	2169.500
Z	-2.457
Asymp. Sig. (2-tailed)	.014

a. Grouping Variable: HANDSTEST23

Test Statistics[a]

	Test3:Test4
Mann-Whitney U	1182.000
Wilcoxon W	2457.000
Z	-.470
Asymp. Sig. (2-tailed)	.638

a. Grouping Variable: HANDSTEST34

Test Statistics[a]

	Test4:Test5
Mann-Whitney U	878.000
Wilcoxon W	2153.000
Z	-2.571
Asymp. Sig. (2-tailed)	.010

a. Grouping Variable: HANDSTEST45

Statistical analysis of the hand swab test by activity of enterprises

Level of bacteria on the first hand swab test

	Restaurants	Fast food	Bakeries	Butcheries
Minimum	2.94	3.00	2.15	3.19
Median	3.09	3.18	2.93	4.00
Mean	3.11	3.35	2.87	3.98
Maximum	3.85	3.86	3.19	4.48
Stand.deviation	0.21	0.35	0.33	0.41

Level of bacteria on the second hand swab test

	Restaurants	Fast food	Bakeries	Butcheries
Minimum	2.70	2.88	1.34	3.00
Median	2.87	3.16	2.70	3.60
Mean	2.88	3.17	2.53	3.63
Maximum	3.61	3.60	3.00	4.00
Stand.deviation	0.23	0.30	0.48	0.31

Level of bacteria on the third hand swab test

	Restaurants	Fast food	Bakeries	Butcheries
Minimum	2.48	2.54	1.70	2.48
Median	2.72	2.88	2.48	3.48
Mean	2.74	2.98	2.42	3.42
Maximum	3.48	3.54	2.88	4.00
Stand.deviation	0.23	0.38	0.34	0.43

Level of bacteria on the fourth hand swab test

	Restaurants	Fast food	Bakeries	Butcheries
Minimum	2.08	2.34	1.70	2.34
Median	2.94	2.93	2.34	3.60
Mean	2.80	2.94	2.38	3.44
Maximum	3.60	3.61	2.94	3.70
Stand.deviation	0.36	0.51	0.38	0.45

Level of bacteria on the fifth hand swab test

	Restaurants	Fast food	Bakeries	Butcheries
Minimum	2.45	2.72	1.95	2.72
Median	2.98	3.18	2.72	3.65
Mean	2.97	3.22	2.71	3.57
Maximum	3.70	3.71	4.00	3.85
Stand.deviation	0.27	0.36	0.49	0.36

Appendix B3: Food analyses

Samples of the results of food analyses

cp. FOODLAB ltd
Χημείο Νερού – Ποτών - Τροφίμων
Λυμάτων - Περιβάλλοντος

Λεωφ. Τσερίου, 2040 Στρόβολος
Τ.Κ. 28729, 2082 Λευκωσία - Κύπρος
Τηλ. : +(357) 22 45 68 60, 1, 2, 3
Κιν. : +(357) 99 42 68 78
Fax. : +(357) 22 32 15 17

ΕΚΘΕΣΗ ΑΠΟΤΕΛΕΣΜΑΤΩΝ

Ονομα : Αρτοποιΐα ΣΤΕ-ΜΑ
: (Δρόμος Τροόδους, Αστρομερίτης)
Αρ. Δείγματος : 33540-46
Δειγματολήπτης : cp FoodLab Ltd
Χαρακτηριστικά Δείγματος : Τρόφιμα σε χάρτινη&νάυλον συσκευασία , θερμοκρασία (8°C).
: όπως φαίνεται πιο κάτω.
Ημερ. Παραλαβής : 25/04/06
Ημερ. Ανάλυσης : 26-28/04/06
Ημερ. Έκδοσης Αποτελεσμάτων : 29/04/06

Αποτελέσματα

Δείγμα	Ολικός αρ. Βακτηριδίων /g	Κολοβ/οειδή /g	Εντερικά Κολοβ/ρίδια /g	St. aureus (+) /g	Ζύμες & Μύκητες /g	Bac. cereus /g	Salmo. spp /25g
Μέθοδος εξέτασης	ISO 4833: 1991	ISO 4832: 1991	ISO 16649-2: 2001	ISO 6888: 2002	AOAC.18 1998	ISO 7932:93	AOAC2000. 07
33540, Ταχνιόπιττα	<100	<10	<10	<10	30		
33541, Πίτσα ψημένη	<100	<10	<10	<10			
33542, Κουλουράκια	200			<10	200		
33543, Κολοκοτή	<100				30		
33544,Τυρόπιττα άψητη		320	<10	10		–	
33545, Χάμπουρκεκ άψητο		<10	<10	<10			Απουσία
[illegible]546, Πίττες ψημένες	1300			<10			

Σημ.:

1. Τα αποτελέσματα αφορούν μόνο τα δείγματα που έχουν εξεταστεί.
2. Ικανοποιητικά αποτελέσματα.

Για το cp FoodLab Ltd

Χαρά Παπαστεφάνου,
Διευθύντρια

cp. FOODLAB ltd
Χημείο Νερού – Ποτών - Τροφίμων
Λυμάτων - Περιβάλλοντος

Λεωφ. Τσερίου, 2040 Στρόβολος
Τ.Κ. 28729, 2082 Λευκωσία - Κύπρος
Τηλ. : +(357) 22 45 68 60, 1, 2, 3
Κιν. : +(357) 99 42 68 78
Fax. : +(357) 22 32 15 17

ΕΚΘΕΣΗ ΑΠΟΤΕΛΕΣΜΑΤΩΝ

Ονομα : Γιάννης Τουλουπής
: (Λεωφ. Μαζωτού 6, Κίτι)
Αρ. Δείγματος : 31670-73/5
Δειγματολήπτης : cp FoodLab Ltd
Χαρακτηριστικά Δείγματος : 31670, Κοτόπιττα σε αποστειρωμένη συσκευασία,θερμ. (0°C)
: 31671, Κρεατόπιττα >> >>
: 31672, Κρουασάν με φουντούκι >> >>
: 31673, Φεττόπιττα >> >>
: 31675, Ζύμη για τυρόπιττα σε αποστ. συσκευασία, >>
Ημερ. Παραλαβής : 16/ 04/06
Ημε. Ανάλυσης : 17-20/04/06
Ημερ. Έκδοσης Αποτελεσμάτων :22/04/06

Αποτελέσματα

Μεταβλητή	Μέθοδος εξέτασης	Μον	31670	31671	31672	31673	31675
Κολοβακτηριοειδή	ISO 4832: 1991	/g	90	30	6500	3900	24000
Εντερικά κολοβακτηρίδια	ISO 16649-2: 2001	/g	<10	<10	<10	30	40
St. aureus (+)	FDA	/g	80	<10	30	<10	<10
Cl. perfringens	FDA	/g	10	<10			
Bac. cereus	FDA	/g				<20	20
Salmonella spp	FDA	/25g	Απουσία				

Σημ. :

1. Τα αποτελέσματα αφορούν μόνο τα δείγματα που έχουν εξεταστεί.
2. Ικανοποιητικά αποτελέσματα. Να δοθεί περισσότερη προσοχή στο θέμα του σταφυλόκοκκου (δείγμα 31670).

Για το cp FoodLab Ltd

Χαρά Παπαστεφάνου,
Διευθύντρια

Food analysis by activity

Chi-Square Tests

	Value	df	Asymp. Sig. (2- sided)
Pearson Chi-Square	7.170[a]	3	.067
Likelihood Ratio	7.832	3	.050
Linear-by-Linear Association	1.346	1	.246

a. 3 cells (37.5%) have expected count less than 5. The minimum expected count is 3.36.

Chi-Square Tests

	Value	df	Asymp. Sig. (2- sided)
Pearson Chi-Square	4.246[a]	3	.236
Likelihood Ratio	4.480	3	.214
Linear-by-Linear Association	.637	1	.425

a. 3 cells (37.5%) have expected count less than 5. The minimum expected count is 2.40.

Chi-Square Tests

	Value	df	Asymp. Sig. (2- sided)
Pearson Chi-Square	3.492[a]	3	.322
Likelihood Ratio	3.682	3	.298
Linear-by-Linear Association	1.152	1	.283

a. 3 cells (37.5%) have expected count less than 5. The minimum expected count is 2.40.

Chi-Square Tests

	Value	df	Asymp. Sig. (2- sided)
Pearson Chi-Square	3.204[a]	3	.361
Likelihood Ratio	3.330	3	.344
Linear-by-Linear Association	.106	1	.745

a. 3 cells (37.5%) have expected count less than 5. The minimum expected count is 3.52

Chi-Square Tests

	Value	df	Asymp. Sig. (2- sided)
Pearson Chi-Square	5.280[a]	3	.152
Likelihood Ratio	5.828	3	.120
Linear-by-Linear Association	2.290	1	.130

a 4 cells (50.0%) have expected count less than 5. The minimum expected count is 3.68.

Appendix B4: Sample of the results of water analysis

cp. FOODLAB ltd
Χημείο Νερού – Ποτών - Τροφίμων
Λυμάτων - Περιβάλλοντος

Λεωφ. Τσερίου, 2040 Στρόβολος
Τ.Κ. 28729, 2082 Λευκωσία - Κύπρος
Τηλ. : +(357) 22 45 68 60, 1, 2, 3
Κιν. : +(357) 99 42 68 78
Fax. : +(357) 22 32 15 17

ΕΚΘΕΣΗ ΑΠΟΤΕΛΕΣΜΑΤΩΝ

Όνομα	: Αρτοποιΐα ΣΤΕ-ΜΑ
	: (Δρόμος Τροόδους, Αστρομερίτη)
Αρ. Δείγματος	: 33548
Δειγματολήπτης	: cp FoodLab Ltd
Χαρακτηριστικά Δείγματος	: Νερό σε πλαστικό μπουκάλι, θερμοκρασία (7°C).
Ημερ. Παραλαβής	: 15/04/06
Ημερ. Ανάλυσης	: 26/04/06
Ημερ. Έκδοσης Αποτελεσμάτων	: 28/04/06

Αποτελέσματα

Παράμετρος	Μέθοδος εξέτασης	Μονάδα	33548	Αποδ. ανώτατα όρια πόσιμου νερού
pH (20°C)	ΕΛΟΤ:658:83		8.2	6.90-9.50
Αγωγιμότητα	APHA 2510B:98	μS/cm	848	2500
Ολική Σκληρότητα (σαν $CaCO_3$)	ΕΛΟΤ 170:80	mg/l	168	500
Αλκαλικότητα ανθρακικών (σαν $CaCO_3$)	APHA 2320(B):98	mg/l	<1	
Αλκαλικότητα οξ. Ανθρακικών (σαν $CaCO_3$)	APHA 2320(B):98	mg/l	191	
Χλωριούχα (Cl)	APHA 4500-Cl(B):92	mg/l	128	250
Θειικά (SO_4)	APHA 4500-SO_4 (E):1992	mg/l	17	250
Νιτρικά (NO_3)	APHA 4500-NO_3 (E):98	mg/l	<1	50
Νιτρώδη (NO_2-N)	APHA 4500-NO_2 (B):98	mg/l	0.005	0.15
Νάτριο (Na)	APHA 3500-Na (D):92	mg/l	85	200
Κάλιο (K)	APHA 3500-K(D):92	mg/l	1	12
Ασβέστιο (Ca)	APHA 3500-Ca (D):92	mg/l	51	150
Μαγνήσιο (Mg)	APHA 3500-Ca (D):92/ ΕΛΟΤ 170:80	mg/l	10	50

Σημ:

1. Τα αποτελέσματα αφορούν μόνο το δείγμα που έχει εξεταστεί.
2. Όλες οι παράμετροι που εχουν εξεταστεί είναι μέσα στα όρια που καθορίζονται για τα πόσιμα νερά.

Για το cp FoodLab Ltd

Χαρά Παπαστεφάνου
Διευθύντρια

Τέλος Εκθεσης — Σελ. 1/1

Η παρούσα έκθεση έχει επιστημονικό χαρακτήρα και δεν μπορεί να χρησιμοποιηθεί για διαφημιστικούς ή άλλους παρόμοιους σκοπούς χωρίς την γραπτή άδεια του Εργαστηρίου

Το cp FoodLab είναι ανεξάρτητο ιδιωτικό εργαστήριο
E-mail: foodlab@cytanet.com.cy

cp. FOODLAB ltd
Χημείο Νερού – Ποτών - Τροφίμων
Λυμάτων - Περιβάλλοντος

Λεωφ. Τσερίου, 2040 Στρόβολος
Τ.Κ. 28729, 2082 Λευκωσία - Κύπρος
Τηλ. : +(357) 22 45 68 60, 1, 2, 3
Κιν. : +(357) 99 42 68 78
Fax. : +(357) 22 32 15 17

ΕΚΘΕΣΗ ΑΠΟΤΕΛΕΣΜΑΤΩΝ

Ονομα	: Αρτοποιΐα ΣΤΕ-ΜΑ
	: (Λεωφ. Τροόδους, Αστρομερίτη)
Αρ. Δείγματος	: 33547
Δειγματολήπτης	: cp FoodLab Ltd
Χαρακτηριστικά Δείγματος	: Νερό ντεποζίτου σε αποστειρωμένο γυάλινο μπουκάλι
	: σε θερμοκρασία (7°C).
Ημερ. Παραλαβής	: 25/04/06
Ημερ. Ανάλυσης	: 26-29/04/06
Ημερ. Έκδοσης Αποτελεσμάτων	: 01/05/06

Αποτελέσματα

Παράμετρος	Μέθοδος εξέτασης	Μον.	33547	Αποδ. ανώτατα όρια πόσιμου νερού
Ολικός αριθμός Βακτηριδίων (37 °C)	CYS EN 6222:1999	/ml	32	
Κολοβακτηριοειδή	APHA 9222 B:1992	/100ml	Δεν ανιχνεύτηκε	0
F. coliform	APHA 9221 E:1992	/100ml	Δεν ανιχνεύτηκε	0
Εντερόκοκκος	ΕΛΟΤ:947.2:1996	/100ml	Δεν ανιχνεύτηκε	0

Σημ.:

1. Τα αποτελέσματα αφορούν μόνο το δείγμα που έχει εξεταστεί.
2. Ικανοποιητικά αποτελέσματα

Για το cp FoodLab Ltd

[redacted]

Χαρά Παπαστεφάνου,
Διευθύντρια

Τέλος Έκθεσης Σελ. 1/1

Η παρούσα έκθεση έχει επιστημονικό χαρακτήρα και δεν μπορεί να χρησιμοποιηθεί για διαφημιστικούς ή άλλους παρόμοιους σκοπούς χωρίς την γραπτή άδεια του Εργαστηρίου

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E-mail: foodlab@cytanet.com.cy

Appendix B5: Guide of microbiological acceptable limits for food (general laboratory / Ministry of Health / Cyprus)

Πίνακας 1 Κατηγορίες διαφόρων έτοιμων προς κατανάλωση τροφίμων με βάση τον ολικό αριθμό βακτηριδίων

Ομάδα τροφίμου	Είδος τροφίμου	Κατηγορία
Κρέας Meat	Μπιφτέκια	1
	Σουβλάκι και λουκάνικα τύπου Φρανκφούρτης	2
	Χαμ τεμαχισμένο	4
	Χαμ μη τεμαχισμένο	2
	Κρέας τεμαχισμένο (βοδινό, χοιρινό, κοτόπουλο)	3
	Κοτόπουλο μη τεμαχισμένο	2
	Σαλάμι και άλλα κρεατοσκευάσματα ζύμωσης	5
	Λουκάνικα (καπνιστά)	5
Ψάρια Fish	Οστρακοειδή (καβούρι, γαρίδες, αστακός)	3
	Ψάρι (ψημένο)	3
	Ψάρι (καπνιστό)	4
	Γεύματα με ψάρι	3
	Ταραμοσαλάτα	4
	Απομιμήσεις κάβουρα	1
Γλυκίσματα Sweets	Κέικς και γλυκίσματα με φρέσκα κρέμα	3
	Κέικς και γλυκίσματα με κρέμα πατισερί	2
	Κέικς και γλυκίσματα χωρίς κρέμα, στεγνά	1
	Γλυκίσματα ταψιού με σιρόπι	1
	Άλλα είδη αρτοποιίας	1
Φρούτα και λαχανικά Fruits and vegetables	Φρούτα και λαχανικά (ξηρά)	3
	Φρούτα και λαχανικά (φρέσκα)	5
	Ετοιμες μικτές σαλάτες	4
	Ρύζι και πλιγούρι	3
	Λαχανικά και γεύματα λαχανικών ψημένα	2
	Σαλάτα Coleslaw	3
Γαλακτοκομικά Dairies	Τυρί (όλα τα είδη)	5
	Παγωτό (με ή χωρίς γάλα)	2
	Γιαούρτι και παγωτό γιαούρτι	5
Έτοιμα προς κατανάλωση γεύματα	Ζυμαρικά/Πίτσα	2
	Όλα τα είδη έτοιμων γευμάτων	2
Σάντουιτς Sandwich	Με σαλατικά	4
	Χωρίς σαλατικά	3
	Με τυρί ή σαλάμι ή λούντζα ή λουκάνικα καπνιστά	5
Διάφορα Other	Προϊόντα ζύμωσης	5
	Χούμοι, τζαντζίκι και άλλα dips	4
	Μαγιονέζα/salad dressings	2
	Πατέ	3

Πίνακας 2. Κριτήρια για τη μικροβιολογική ποιότητα διαφόρων έτοιμων προς κατανάλωση τροφίμων*

Κατηγορία τροφίμου (βλ. Πιν. 1) Food Category	Κριτήριο/Παράμετρος Critiria/Bacteria	Κατάταξη δείγματος - Βαθμίδα μικροβιολογικής ποιότητας (CFU ανά g ή ml)			
		Ικανοποιητικό Acceptable	Οριακά Αποδεκτό Marginal	Υποβαθμισμένο Base	Ακατάλληλο/ Δυνητικά επικίνδυνο†
	Ολικός αριθμός βακτηριδίων ** 30°C / 72ώρες**				
1		$<10^3$	10^3-$<10^4$	$\geq 10^4$	—
2		$<10^4$	10^4-$<10^5$	$\geq 10^5$	—
3		$<10^5$	10^5-$<10^6$	$\geq 10^6$	—
4		$<10^6$	10^6-$<10^7$	$\geq 10^7$	—
5		Δ.Ε.	Δ.Ε.	Δ.Ε.	Δ.Ε.
	Μικροοργανισμοί Δείκτες≠				
1-5	*E.coli*	<20	20-<100	100-$<10^4$	$\geq 10^4$
	Listeria spp.	<20	20-<100	>100	—
	Παθογόνοι Μικροοργανισμοί				
1-5	*Salmonella spp.*	Απουσία στα 25 g			Παρουσία στα 25 g
	Campylobacter spp.	Απουσία στα 25g			Παρουσία στα 25 g
	V.cholerae	Απουσία στα 25g			Παρουσία στα 25 g
	V.parahaemolyticus¶	Απουσία στα 25g			Παρουσία στα 25 g
	L.monocytogenes	Απουσία στα 25g			Παρουσία στα 25 g
	Staphylococcus aureus	<20	20-<100	100-$<10^4$	$\geq 10^4$
	Clostridium perfringens	<20	20-<100	100-$<10^4$	$\geq 10^4$
	Bacillus cereus και άλλοι παθογόνοι βάκιλλοι#	$<10^3$	10^3-$<10^4$	10^4-$<10^5$	$\geq 10^5$

Δ.Ε = *Δεν εφαρμόζεται*

CFU = *Colony forming units (αριθμός αποικιών)*

* *Η αναφορά σε συγκεκριμένη παράμετρο δεν επιβάλλει κατανάγκην και τον έλεγχο του τροφίμου για την παράμετρο αυτή πάνω σε βάση ρουτίνας.*

† *Ποινική δίωξη βασισμένη μόνο σε ολικό αρ. βακτηριδίων και μικροοργανισμούς δείκτες μπορεί να γίνει σε περιπτώσεις που κρίνεται αναγκαίο λόγω αδικαιολόγητα αυξημένων αριθμών.*

≠ *Σε κάποιες περιπτώσεις μπορεί να είναι παθογόνοι π.χ. E.coli 0157. Εδώ εφαρμόζονται αυστηρότερα κριτήρια.*

¶ *Μόνο στα ψάρια. Εφαρμόζεται και στα ωμά/κατεψυγμένα ψάρια.*

** *Στα προϊόντα ζύμωσης (γιαούρτι, σαλάμι κλπ) δεν ελέγχεται ο ολικός αρ. βακτηριδίων.*

\# *Συνήθως B. subtilis, B. licheniformis and B. pumilus. Αν ο αριθμός των βακίλλων είναι πάνω από 10^4 cfu/g τότε συστήνεται όπως ο οργανισμός ταυτοποιείται.*

Appendix C: Tests

Appendix C1: Test 1

Test 1

Level ……..

Instructions:

This test consists of two parts (Part A and Part B). Both parts must be answered. Each Part is worth 10 marks. The total mark of the test is 20 marks. The base of the test is 10. The time allowed is 30 minutes for each part.

PART A:

Part A consists of 5 questions. Answer ALL questions providing an analyzed answer for each question. Each question is worth 2 marks.

Question 1

How does HACCP enhance food safety?

Question 2

What food safety issues does HACCP address?

Question 3

What type of records must be kept and whose responsibility is that?

Question 4

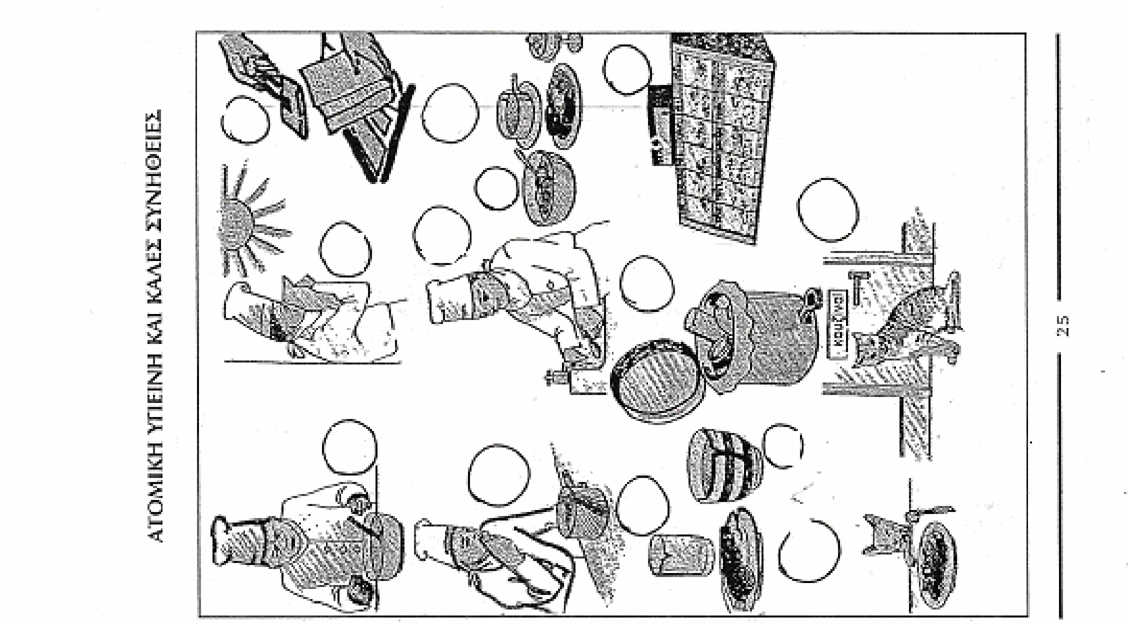
How Does HACCP Work in Food Production?

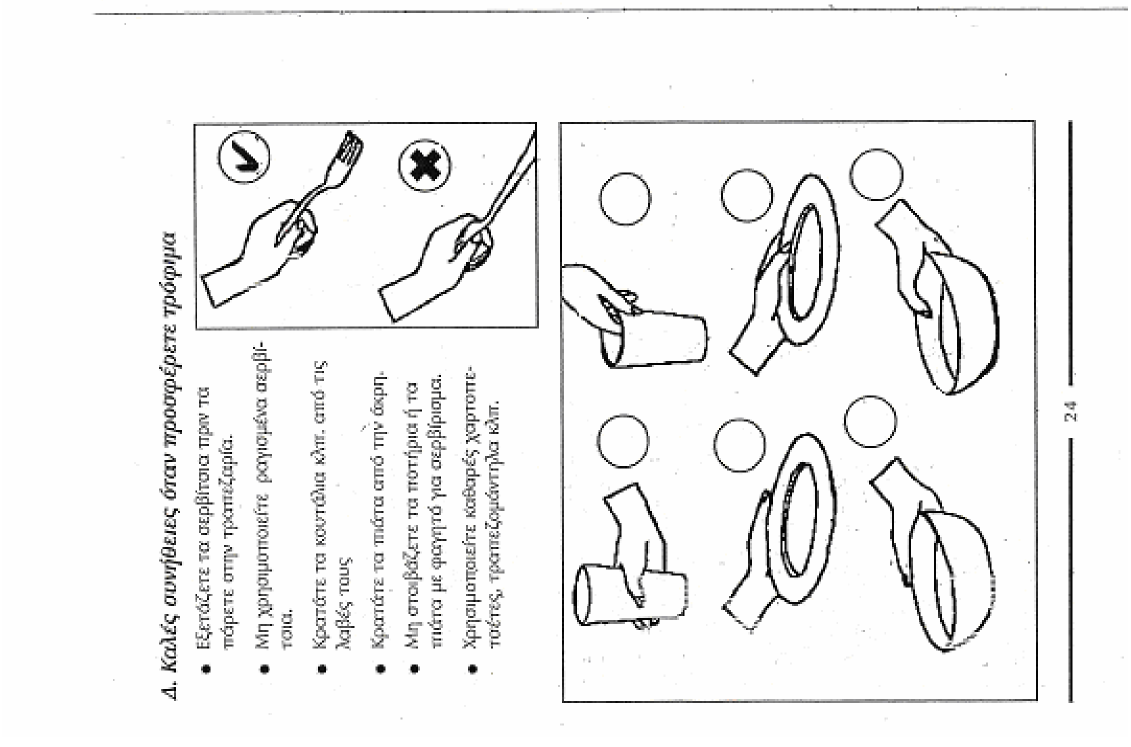
Question 5

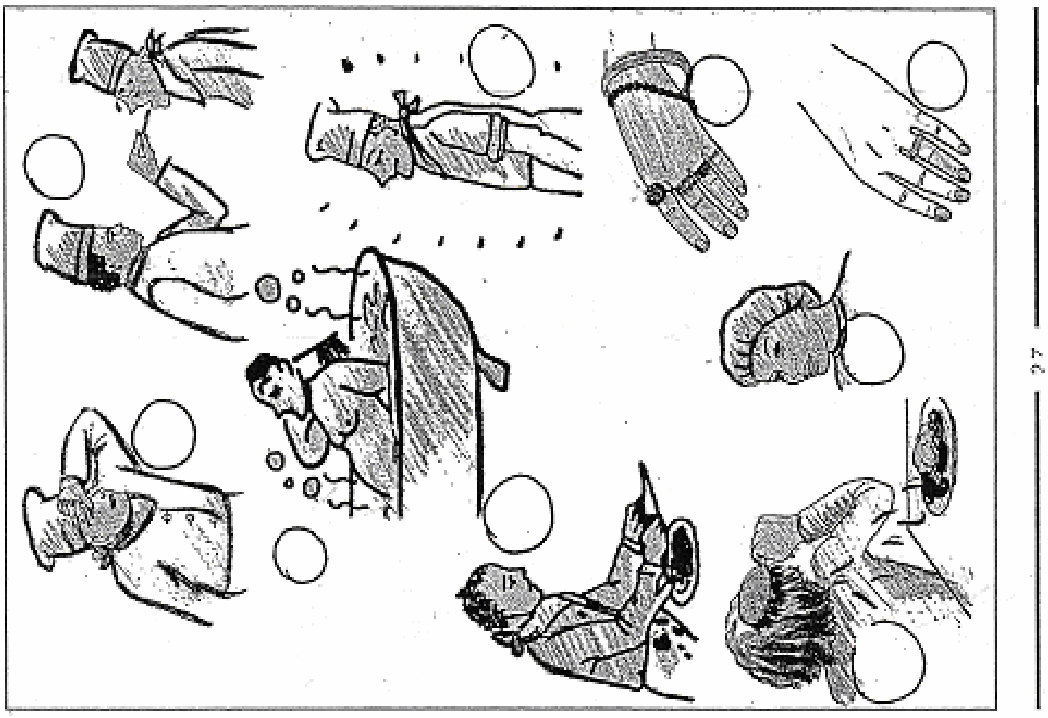
How Would HACCP Be Applied From Farm to Table?

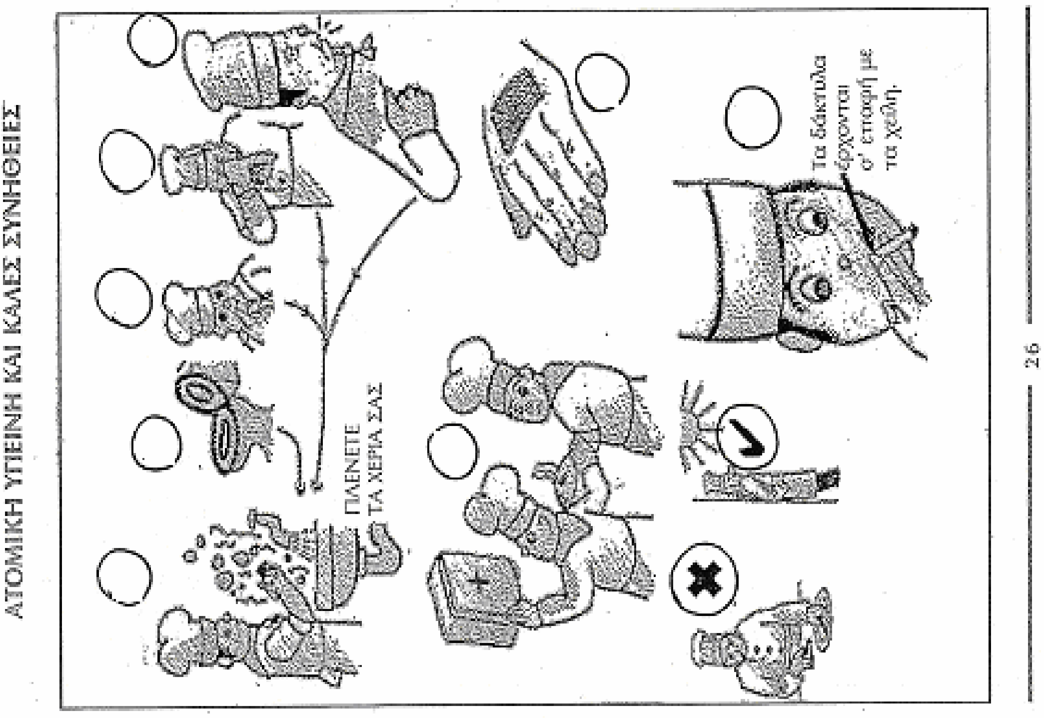
PART B:

On the following pictures mark in the circle an X for a wrong activity and a √ for a correct activity. Each correct answer is worth 0.25.






2 7


ΑΤΟΜΙΚΗ ΥΓΙΕΙΝΗ ΚΑΙ ΚΑΛΕΣ ΣΥΝΗΘΕΙΕΣ
ΠΛΕΝΕΤΕ ΤΑ ΧΕΡΙΑ ΣΑΣ
Τα δάκτυλα έρχονται σ' επαφή με τα χείλη.
2 6

Appendix C2: Test 2

Test 2

Level …..

Instructions:

This test consists of two parts (Part A and Part B). Both parts must be answered. Each Part is worth 10 marks. The total mark of the test is 20 marks. The base of the test is 10. The time allowed is 30 minutes for each part.

PART A:

Part A consists of 5 questions. Answer ALL questions providing an analyzed answer for each question. Each question is worth 2 marks.

Question 1

How does HACCP enhance food safety?

Question 2

What food safety issues does HACCP address?

Question 3

What type of records must be kept and whose responsibility is that?

Question 4

How Does HACCP Work in Food Production?

Question 5

How Would HACCP Be Applied From Farm to Table?

PART B:

Part B consists of 10 multiple choice questions. Only one question is correct. Each question is worth 1 mark.

1. During the inspection of frozen incoming products I check:

A) Car’s temperature, product’s temperature, expiry date
B) Expiry date
C) Only the temperature of the products
D) None of the above

2. During dry food storage the food is:

A) Placed on the floor
B) Placed on the shelves
C) Placed on the shelves with the appropriate labeling
D) None of the above

3. Which is the most dangerous for food safety that is present on the cross contamination area?

A) Equipment
B) Laborer
C) Insects and pests
D) All of the above

4. Which is the critical temperature zone through which most of the pathogen microorganisms are developed and multiplied?

A) 10°C - 50°C
B) 5°C - 63°C
C) 1°C - 60°C
D) None of the above

5. In which way can cross contamination be constrained?

A) Separation of the preparation areas

B) Separation of the equipment

C) In both ways

D) None of the above

6. When food is on the refrigerator microbial:

A) are killed

B) Can not get in

C) Are hibernated and thus can not multiply

D) None of the above

7. Food that is reheated

A) Is discarded

B) As long as I reheat it there is no problem. For this reason the food can be used over and over again.

C) Is placed in the freeze

D) None of the above

8. Why is it important to wash our hands?

A) So that they smell nice

B) Because we can transmit various microbial with our hands

C) Because it is the company's policy

D) All of the above

9. How often do we have to wash our hands?

A) Every hour

B) After the manipulation of meat

C) After any possibility of contaminating the food

D) None of the above

10. Find the mistakes, if they exist, to the following:

A) For the defrost of food I use hot water

B) The allowed time of abidance for the food to cold is 3 hours

C) The preservation temperature of hot food is above 63°C

D) The cooking temperature of the food must be 75°C or above

Appendix C3: Test 3

Test 3

Level: ………

Instructions:

This test consists of two parts (Part A and Part B). Both parts must be answered. Each Part is worth 10 marks. The total mark of the test is 20 marks. The base of the test is 10. The time allowed is 30 minutes for Part A, and 45 minutes for Part B.

PART A:

Part A consists of 5 questions. Answer ALL questions providing an analyzed answer for each question. Each question is worth 2 marks.

Question 1

How does HACCP enhance food safety?

Question 2

What food safety issues does HACCP address?

Question 3

What type of records must be kept and whose responsibility is that?

Question 4

How Does HACCP Work in Food Production?

Question 5

How Would HACCP Be Applied From Farm to Table?

PART B:

Part B consists of 20 multiple choice questions. Only one question is correct. Each question is worth 0.5 mark.

1. A requirement for the implementation of the HACCP system is:

A) existence of a cleaning program for the ceiling of the building
B) check of the impact of temperature of the process area in the safety of the product
C) the water that is used to the production to agree with the requirements ΦΕΚ379Β/86 & 53Β/86
D) all of the above
E) none of the above

2. The inspector can confirm the completion of the agreed corrective measures:

A) with confirmation of the corrective action in the place where the audit was performed
B) with evaluation of the submitted proofs
C) in the next scheduled audit
D) all of the above
E) none of the above

3. The inspectors can collect objective proofs from:

A) interviews with the personnel
B) observation of the activities
C) documentation proof reading
D) all of the above
E) none of the above

4. The standards for handling food safety include:

A) requirements for health and safety
B) requirements of relevant documentation on good manufacture practice
C) requirements of the correct cultivation practice
D) all of the above
E) none of the above

5. For the seven principles of the HACCP to be fully developed, it must include

A) commitment by the management

B) evaluation of the suppliers

C) identification and traceability of the product

D) all of the above

E) none of the above

6. The biological hazards on foods are defined as:

A) micro organisms who cause undesirable deformation of the characteristics of the food

B) micro organisms that are possible to cause illness to the consumer

C) micro organisms producing combinations that can cause bad smell in the meat

D) all of the above

E) none of the above

7. The food protection from pathogen micro organisms can be accomplished

A) with the supply of raw materials with no microbiological hazards

B) with careful examination of temperature conditions – during storage of the products

C) by applying the Good Manufacturing Practice (GMP)

D) all of the above

E) none of the above

8. Which of the following parameters are possible to slow down the growth of the pathogen micro organisms in food?

A) Use of the right detergents for surface cleaning

B) Use of a disinfectant substance for the sanitation of the personnel's' hands

C) The change of the pH and water activity (a_w) levels in the food

D) All of the above

E) None of the above

9. What is the effect of pasteurization in the food?

A) It destroys the germinative forms of the pathogen micro organisms

B) It destroys the seeds of the pathogen micro organisms

C) The food is retained for a long time

D) All of the above

E) None of the above

10. Which of the following pathogen micro organisms are sporogenic under certain conditions?

A) *Salmonella spp*

B) *Staphylococcus aureus*

C) *Bacillus cereus*

D) All of the above

E) None of the above

11. Which of the following pathogen micro organisms can grow, even slowly, in very low temperatures (minimum growth temperature 0˚C) causing problems even in products that are preserved under refrigeration (e.g. milk)?

A) *Salmonella spp*

B) *Staphylococcus aureus*

C) *Listeria monocytogenes*

D) All of the above

E) None of the above

12. Which of the following pathogen micro organisms can grow in, comparatively, low values of water activity levels (a_w =0,86)?

A) *Esherichia coli*

B) *Cambylobacter aureus*

C) *Staphylococcus aureus*

D) All of the above

E) None of the above

13. Some micro organisms are specifically resistant in the changes of the PH values as well as of the water activity levels (a_w). These belong in the group of

A) parasites
B) bacteria
C) yeast and fungus
D) all of the above
E) None of the above

14. A food is considered dangerous of consisting of chemical hazards to a person when it contains:

A) toxins of pathogen micro organisms
B) remains of heavy metals
C) remains of substances
D) all of the above
E) none of the above

15. The histamine intoxication is caused from consumption of

A) pasteurised milk
B) delicatessen
C) A type of fish
D) All of the above
E) None of the above

16. For the tracing of the physical hazards there are various preventing measures like:

A) metal detector
B) existence of dredges and filters
C) proper conservation preventing programs
D) all of the above
E) none of the above

17. The application of health measures in areas of food processing aim

A) in avoiding the microbial burden of the food that still has not been through a sanitation stage (e.g. pasteurization)

B) in the prevention of contamination of the product that has already been sanitized

C) in the cleaning and sanitation of the utensils and equipment that are in a direct contact with the food

D) all of the above

E) none of the above

18. The cleaning cycle and sanitation usually begins after the end of the productive activities and includes some main stages that have to be performed in a specific order. This is:

A) removal of product remains $\rightarrow$ pre-soak with water and removal of light $\rightarrow$ cleaning with detergent solution $\rightarrow$ washing out the detergent $\rightarrow$ sanitation with disinfectant $\rightarrow$ washing out with clear water

B) sanitation with disinfectant $\rightarrow$ pre-soak with water and removal of light $\rightarrow$ cleaning with detergent solution $\rightarrow$ washing out the detergent

C) cleaning with detergent solution $\rightarrow$ washing out the detergent $\rightarrow$ sanitation with disinfectant $\rightarrow$ washing out with clear water

D) the order of the above stages does not count

E) none of the above

19. The documentation for cleaning and sanitation must include

A) ground plan with a mark of the clean and infected area

B) study & cleaning and sanitation program

C) documentation for suitability of all chemical and disinfectants for use on food processing areas

D) all of the above

E) none of the above

20. The water documentation must include

A) collection points

B) measures of remaining calcium

C) infrastructure operation permission

D) all of the above

E) none of the above

Appendix D: Questionnaires

Appendix D1: Questionnaire

ΕΡΩΤΗΜΑΤΟΛΟΓΙΟ
QUESTIONNAIRE

Level: …………..

Το ερωτηματολόγιο αφορά το σύστημα διαχείρισης ασφάλειας τροφίμων HACCP και την εφαρμογή του στην βιομηχανία / επιχείρηση σας. Παρακαλώ όπως συμπληρώσετε τις ακόλουθες ερωτήσεις κυκλώνοντας τον κατάλληλο αριθμό σχετικά με τις απόψεις σας για κάθε δήλωση. Ο αριθμός 1 αντιστοιχεί με το μικρότερο βαθμό και ο αριθμός 6 αντιστοιχεί με τον μεγαλύτερο βαθμό.

This questionnaire is about HACCP and its implementation in your business. A series of questions and statements are listed below and you are asked to answer the questions and state whether you agree or disagree about each statement. Please read each question carefully and circle the responses that most match how you feel about each statement. Number 1 indicates the lowest value and number 6 the highest value.

Γενικές πληροφορίες για την επιχείρηση
General information about your business

1. Όνομα επιχείρησης. ……………………………………………………………………
   Your business name

2. Πόσο καιρό λειτουργεί η επιχείρηση; ………………………………………………
   How long have you been running this business?

3. Πόσα άτομα εργάζονται στην επιχείρηση; …………………………………………
   How many people work here?

4. Τι είδη τροφίμων διαθέτει η επιχείρηση σας; ………………………………………
   What kind of food do you produce?

5. Πιστεύετε ότι είναι υψηλού κινδύνου τα τρόφιμα τα οποία επεξεργάζεστε;
   Do you believe that you deal with high risk food?

Ναι / Yes ☐ Όχι / No ☐

Αρ./No.	Ερωτήσεις/Questions
1.	Πόσο ευέλικτο νομίζετε ότι είναι το σύστημα HACCP? How flexible do you think HACCP system is? 1 2 3 4 5 6
2.	Πόσο εύκολα μπορεί να εφαρμοστεί το σύστημα HACCP στην κατηγορία των μικρομεσαίων επιχειρήσεων στην οποία ανήκει και η δική σας εταιρεία; How easily can HACCP system be implemented in the category of small and medium enterprises like the company that you belong? 1 2 3 4 5 6
3.	Πόσο γραφειοκρατικό πιστεύετε ότι είναι το σύστημα; How bureaucratic to do think the system is? 1 2 3 4 5 6
4.	Πόσο δύσκολο με βάση τις γνώσεις σας είναι να τηρείτε τα αρχεία του συστήματος; Based on your knowledge how difficult is it to keep the system's records? 1 2 3 4 5 6
5.	Πόσο δαπανηρή θεωρείτε ότι είναι η εφαρμογή του συστήματος με βάση το μέγεθος της εταιρείας σας; How costly do you think the application of the system is, based on the size of your company? 1 2 3 4 5 6

6.	Σε ποιο βαθμό πιστεύετε ότι η εφαρμογή του συστήματος είναι πολύπλοκη για το μέγεθος της εταιρείας σας; How complicated do you think the system is based on the size of your company? 1 2 3 4 5 6
7.	Σε ποιο βαθμό πιστεύετε ότι το σύστημα HACCP που εφαρμόζετε αποτελεί χρήσιμο εργαλείο; In your opinion in what degree is the HACCP system useful for your company? 1 2 3 4 5 6
8.	Σε ποιο βαθμό πιστεύετε ότι έχουν μειωθεί τα παράπονα των πελατών σας με την εφαρμογή του συστήματος; To what degree have the customers' complaints been reduced with the application of the system? 1 2 3 4 5 6
9.	Σε ποιο βαθμό πιστεύετε ότι έχουν βελτιωθεί τα αποτελέσματα των προϊόντων σας με την εφαρμογή του συστήματος; To what degree have your products been improved with the application of the system? 1 2 3 4 5 6
10.	Σε ποιο βαθμό πιστεύετε ότι έχουν βελτιωθεί τα αποτελέσματα των swab tests με την εφαρμογή του συστήματος; To what degree have the results of the swab tests been improved with the application of the system? 1 2 3 4 5 6

11.	Σε ποιο βαθμό πιστεύετε ότι έχουν βελτιωθεί τα αποτελέσματα των επιθεωρήσεων της εταιρείας σας με την εφαρμογή του συστήματος; To what degree have the audit results of your company been improved with the application of the system? 1 2 3 4 5 6
12.	Σε ποιο βαθμό νιώθετε να σας βοήθησε στη καθημερινή σας εργασία το σύστημα; To what degree did the system help you in your every day work? 1 2 3 4 5 6
13.	Σε ποιο βαθμό σας βοήθησε το σύστημα να βελτιώσετε τις γνώσεις σας; To what degree did the system help you to improve your knowledge? 1 2 3 4 5 6
14.	Έχετε σκεφτεί να σταματήσετε την εφαρμογή του συστήματος; Did you ever think to stop the application of the system? Ναι / Yes ☐ Όχι / No ☐

Appendix D2: Statistical Analysis of the Questionnaire

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Question1 E1	50	4.08	.829	3	6
Question1 E2	50	3.56	.760	1	5
Question1 E3	50	2.08	.665	1	3
Question1 E4	50	1.58	.642	1	3

Test Statistics[a]

N	50.000
Chi-Square	139.625
Df	3.000
Asymp. Sig.	.000

a. Friedman Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 1 E2 - E1	Negative Ranks	22[a]	12.11	266.50
	Positive Ranks	1[b]	9.50	9.50
	Ties	27[c]		
	Total	50		

a. E2 < E1

b. E2 > E1

c. E2 = E1

Test Statistics[b]

	E2 - E1
Z	-4.153[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 1 E3 – E2	Negative Ranks	49[a]	25.00	1225.00
	Positive Ranks	0[b]	.00	.00
	Ties	1[c]		
	Total	50		

a. E3 < E2

b. E3 > E2

c. E3 = E2

Test Statistics[b]

	E3 - E2
Z	-6.286[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 1 E4 – E3	Negative Ranks	25[a]	13.00	325.00
	Positive Ranks	0[b]	.00	.00
	Ties	25[c]		
	Total	50		

a. E4 < E3

b. E4 > E3

c. E4 = E3

Test Statistics[b]

	E4 - E3
Z	-5.000[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Question 2 E1	50	4.20	.808	3	6
Question 2 E2	50	3.66	.626	3	5
Question 2 E3	50	1.88	.659	1	3
Question 2 E4	50	1.26	.527	1	3

Test Statistics[a]

N	50.000
Chi-Square	138.384
Df	3.000
Asymp. Sig.	.000

a. Friedman Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 2 E2 – E1	Negative Ranks	26[a]	13.50	351.00
	Positive Ranks	0[b]	.00	.00
	Ties	24[c]		
	Total	50		

a. E2 < E1

b. E2 > E1

c. E2 = E1

Test Statistics[b]

	E2 - E1
Z	-5.014[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 2 E3 – E2	Negative Ranks	47[a]	24.00	1128.00
	Positive Ranks	0[b]	.00	.00
	Ties	3[c]		
	Total	50		

a. E3 <E2

b. E3 > E2

c. E3 = E2

Test Statistics[b]

	E3 - E2
Z	-6.268[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 2 E4 – E3	Negative Ranks	26[a]	13.50	351.00
	Positive Ranks	0[b]	.00	.00
	Ties	24[c]		
	Total	50		

a. E4 < E3

b. E4 > E3

c. E4 = E3

Test Statistics[b]

	E4 - E3
Z	-4.767[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Question 3 E1	50	2.52	.863	1	4
Question 3 E2	50	3.74	.751	2	6
Question 3 E3	50	5.00	.756	4	6
Question 3 E4	50	5.62	.602	4	6

Test Statistics[a]

N	50.000
Chi-Square	135.612
df	3.000
Asymp. Sig.	.000

a. Friedman Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 3 E2 – E1	Negative Ranks	0[a]	.00	.00
	Positive Ranks	44[b]	22.50	990.00
	Ties	6[c]		
	Total	50		

a. E2 < E1

b. E2 > E1

c. E2 = E1

Test Statistics[b]

	E2 - E1
Z	-5.989[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 3 E3 – E2	Negative Ranks	0[a]	.00	.00
	Positive Ranks	39[b]	20.00	780.00
	Ties	11[c]		
	Total	50		

a. E3 < E2

b. E3 > E2

c. E3 = E2

Test Statistics[b]

	E3 - E2
Z	-5.570[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 3 E4 – E3	Negative Ranks	1[a]	6.00	6.00
	Positive Ranks	21[b]	11.76	247.00
	Ties	28[c]		
	Total	50		

a. E4 < E3

b. E4 > E3

c. E4 = E3

Test Statistics[b]

	E4 - E3
Z	-4.031[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Question 4 E1	50	2.16	.842	1	5
Question 4 E2	50	3.82	.873	3	6
Question 4 E3	50	5.36	.485	5	6
Question 4 E4	50	5.82	.388	5	6

Test Statistics[a]

N	50.000
Chi-Square	141.976
df	3.000
Asymp. Sig.	.000

a. Friedman Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 4 E2 – E1	Negative Ranks	0[a]	.00	.00
	Positive Ranks	49[b]	25.00	1225.00
	Ties	1[c]		
	Total	50		

a. E2 < E1

b. E2 > E1

c. E2 = E1

Test Statistics[b]

	E2 - E1
Z	-6.235[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 4 E3 – E2	Negative Ranks	0[a]	.00	.00
	Positive Ranks	45[b]	23.00	1035.00
	Ties	5[c]		
	Total	50		

a. E3 < E2

b. E3 > E2

c. E3 = E2

Test Statistics[b]

	E3 - E2
Z	-6.017[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 4 E4 – E3	Negative Ranks	0[a]	.00	.00
	Positive Ranks	23[b]	12.00	276.00
	Ties	27[c]		
	Total	50		

a. E4 < E3

b. E4 > E3

c. E4 = E3

Test Statistics[b]

	E4 - E3
Z	-4.796[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Question 5 E1	50	3.86	.808	2	6
Question 5 E2	50	4.44	.675	3	6
Question 5 E3	50	5.28	.640	4	6
Question 5 E4	50	5.28	.640	4	6

Test Statistics[a]

N	50.000
Chi-Square	120.435
Df	3.000
Asymp. Sig.	.000

a. Friedman Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 5 E2 – E1	Negative Ranks	2[a]	15.00	30.00
	Positive Ranks	29[b]	16.07	466.00
	Ties	19[c]		
	Total	50		

a. E2 < E1

b. E2 > E1

c. E2 = E1

Test Statistics[b]

	E2 - E1
Z	-4.761[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 5 E3 – E2	Negative Ranks	0[a]	.00	.00
	Positive Ranks	38[b]	19.50	741.00
	Ties	12[c]		
	Total	50		

a. E3 < E2

b. E3 > E2

c. E3 = E2

Test Statistics[b]

	E3 - E2
Z	-5.962[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 5 E4 – E3	Negative Ranks	0[a]	.00	.00
	Positive Ranks	0[b]	.00	.00
	Ties	50[c]		
	Total	50		

a. E4 < E3

b. E4 > E3

c. E4 = E3

Test Statistics[b]

	E4 - E3
Z	.000[a]
Asymp. Sig. (2-tailed)	1.000

a. The sum of negative ranks equals the sum of positive ranks.

b. Wilcoxon Signed Ranks Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Question 6 E1	50	2.44	.951	1	5
Question 6 E2	50	3.58	.835	2	5
Question 6 E3	50	5.08	.665	4	6
Question 6 E4	50	5.66	.557	4	6

Test Statistics[a]

N	50.000
Chi-Square	138.994
df	3.000
Asymp. Sig.	.000

a. Friedman Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 6 E2 – E1	Negative Ranks	2[a]	13.50	27.00
	Positive Ranks	40[b]	21.90	876.00
	Ties	8[c]		
	Total	50		

a. E2 < E1

b. E2 > E1

c. E2 = E1

Test Statistics[b]

	E2 – E1
Z	-5.487[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 6 E3 – E2	Negative Ranks	0[a]	.00	.00
	Positive Ranks	48[b]	24.50	1176.00
	Ties	2[c]		
	Total	50		

a. E3 < QE

b. E3 > QE

c. E3 = QE

Test Statistics[b]

	E3 - E2
Z	-6.189[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 6 E4 – E3	Negative Ranks	0[a]	.00	.00
	Positive Ranks	25[b]	13.00	325.00
	Ties	25[c]		
	Total	50		

a. E4 < E3

b. E4 > E3

c. E4 = E3

Test Statistics[b]

	E4 - E3
Z	-4.716[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Question 7 E1	50	3.58	.883	2	5
Question 7 E2	50	3.58	.883	2	5
Question 7 E3	50	2.18	.774	1	4
Question 7 E4	50	1.64	.563	1	3

Test Statistics[a]

N	50.000
Chi-Square	144.191
Df	3.000
Asymp. Sig.	.000

a. Friedman Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 7 E2 – E1	Negative Ranks	0[a]	.00	.00
	Positive Ranks	0[b]	.00	.00
	Ties	50[c]		
	Total	50		

a. E2 < E1

b. E2 > E1

c. E2 = E1

Test Statistics[b]

	E2 - E1
Z	.000[a]
Asymp. Sig. (2-tailed)	1.000

a. The sum of negative ranks equals the sum of positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 7 E3 – E2	Negative Ranks	49[a]	25.00	1225.00
	Positive Ranks	0[b]	.00	.00
	Ties	1[c]		
	Total	50		

a. E3 < E2

b. E3 > E2

c. E3 = E2

Test Statistics[b]

	E3 - E2
Z	-6.299[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 7 E4 – E3	Negative Ranks	26[a]	13.50	351.00
	Positive Ranks	0[b]	.00	.00
	Ties	24[c]		
	Total	50		

a. E4 < E3

b. E4 > E3

c. E4 = E3

Test Statistics[b]

	E4 - E3
Z	-5.014[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Question 8 E1	50	3.44	1.091	1	5
Question 8 E2	50	3.22	.887	1	5
Question 8 E3	50	2.50	.814	1	4
Question 8 E4	50	1.90	.707	1	3

Test Statistics[a]

N	50.000
Chi-Square	83.719
df	3.000
Asymp. Sig.	.000

a. Friedman Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 8 E2 – E1	Negative Ranks	15[a]	9.60	144.00
	Positive Ranks	5[b]	13.20	66.00
	Ties	30[c]		
	Total	50		

a. E2 < E1

b. E2 > E1

c. E2 = E1

Test Statistics[b]

	E2 - E1
Z	-1.520[a]
Asymp. Sig. (2-tailed)	.128

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 8 E3 – E2	Negative Ranks	31[a]	17.23	534.00
	Positive Ranks	2[b]	13.50	27.00
	Ties	17[c]		
	Total	50		

a. E3 < E2

b. E3 > E2

c. E3 = E2

Test Statistics[b]

	E3 – E2
Z	-4.826[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 8 E4 – E3	Negative Ranks	24[a]	12.50	300.00
	Positive Ranks	0[b]	.00	.00
	Ties	26[c]		
	Total	50		

a. E4 < E3

b. E4 > E3

c. E4 = E3

Test Statistics[b]

	E4 - E3
Z	-4.524[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Question 9 E1	50	2.34	.823	1	4
Question 9 E2	50	2.52	.762	1	4
Question 9 E3	50	1.96	.669	1	3
Question 9 E4	50	1.58	.538	1	3

Test Statistics[a]

N	50.000
Chi-Square	69.511
df	3.000
Asymp. Sig.	.000

a. Friedman Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 9 E2 – E1	Negative Ranks	0[a]	.00	.00
	Positive Ranks	7[b]	4.00	28.00
	Ties	43[c]		
	Total	50		

a. E2 < E1
b. E2 > E1
c. E2 = E1

Test Statistics[b]

	E2 - E1
Z	-2.460[a]
Asymp. Sig. (2-tailed)	.014

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 9 E3 – E2	Negative Ranks	22[a]	11.50	253.00
	Positive Ranks	0[b]	.00	.00
	Ties	28[c]		
	Total	50		

a. E3 < E2
b. E3 > E2
c. E3 = E2

Test Statistics[b]

	E3 - E2
Z	-4.350[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.
b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 9 E4 – E3	Negative Ranks	19[a]	10.00	190.00
	Positive Ranks	0[b]	.00	.00
	Ties	31[c]		
	Total	50		

a. E4 < E3
b. E4 > E3
c. E4 = E3

Test Statistics[b]

	E4 – E3
Z	-4.359[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.
b. Wilcoxon Signed Ranks Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Question 10 E1	50	2.74	.922	1	5
Question 10 E2	50	2.42	.928	1	5
Question 10 E3	50	2.02	.742	1	4
Question 10 E4	50	2.38	.987	1	4

Test Statistics[a]

N	50.000
Chi-Square	42.548
df	3.000
Asymp. Sig.	.000

a. Friedman Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 10 E2 – E1	Negative Ranks	11[a]	6.00	66.00
	Positive Ranks	0[b]	.00	.00
	Ties	39[c]		
	Total	50		

a. E2 < E1

b. E2 > E1

c. E2 = E1

Test Statistics[b]

	E2 - E1
Z	-3.017[a]
Asymp. Sig. (2-tailed)	.003

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 10 E3 – E2	Negative Ranks	18[a]	9.50	171.00
	Positive Ranks	0[b]	.00	.00
	Ties	32[c]		
	Total	50		

a. E3 < E2

b. E3 > E2

c. E3 = E2

Test Statistics[b]

	E3 - E2
Z	-4.066[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 10 E4 – E3	Negative Ranks	0[a]	.00	.00
	Positive Ranks	16[b]	8.50	136.00
	Ties	34[c]		
	Total	50		

a. E4 < E3

b. E4 > E3

c. E4 = E3

Test Statistics[b]

	E4 - E3
Z	-3.819[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Question 11 E1	50	4.58	.835	3	6
Question 11 E2	50	4.00	.782	3	6
Question 11 E3	50	2.66	1.042	1	5
Question 10 E4	50	2.02	.742	1	4

Test Statistics[a]

N	50.000
Chi-Square	117.529
df	3.000
Asymp. Sig.	.000

a. Friedman Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 11 E2 – E1	Negative Ranks	18[a]	10.31	185.50
	Positive Ranks	1[b]	4.50	4.50
	Ties	31[c]		
	Total	50		

a. E2 < E1

b. E2 > E1

c. E2 = E1

Test Statistics[b]

	E2 - E1
Z	-3.737[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 11 E3 – E2	Negative Ranks	37[a]	19.88	735.50
	Positive Ranks	1[b]	5.50	5.50
	Ties	12[c]		
	Total	50		

a. E3 < E2

b. E3 > E2

c. E3 = E2

Test Statistics[b]

	E3 - E2
Z	-5.497[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 11 E4 – E3	Negative Ranks	22[a]	12.23	269.00
	Positive Ranks	1[b]	7.00	7.00
	Ties	27[c]		
	Total	50		

a. E4 < E3

b. E4 > E3

c. E4 = E3

Test Statistics[b]

	E4 - E3
Z	-4.101[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Question 12 E1	50	3.24	1.061	1	5
Question 12 E2	50	4.04	.699	3	6
Question 12 E3	50	2.70	.763	1	4
Question 12 E4	50	1.24	.431	1	2

Test Statistics[a]

N	50.000
Chi-Square	115.541
df	3.000
Asymp. Sig.	.000

a. Friedman Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 12 E2 – E1	Negative Ranks	2[a]	21.50	43.00
	Positive Ranks	33[b]	17.79	587.00
	Ties	15[c]		
	Total	50		

a. E2 < E1

b. E2 > E1

c. E2 = E1

Test Statistics[b]

	E2 - E1
Z	-4.673[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 12 E3 – E2	Negative Ranks	41[a]	21.00	861.00
	Positive Ranks	0[b]	.00	.00
	Ties	9[c]		
	Total	50		

a. E3 < E2

b. E3 > E2

c. E3 = E2

Test Statistics[b]

	E3 - E2
Z	-5.737[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 12 E4 – E3	Negative Ranks	40[a]	20.50	820.00
	Positive Ranks	0[b]	.00	.00
	Ties	10[c]		
	Total	50		

a. E4 < E3

b. E4 > E3

c. E4 = E3

Test Statistics[b]

	E4 - E3
Z	-5.636[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Question 13 E1	50	4.38	.923	3	6
Question 13 E2	50	4.78	.708	4	6
Question 13 E3	50	4.42	.835	3	6
Question 13 E4	50	3.84	.842	2	6

Test Statistics[a]

N	50.000
Chi-Square	49.245
df	3.000
Asymp. Sig.	.000

a. Friedman Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 13 E2 – E1	Negative Ranks	0[a]	.00	.00
	Positive Ranks	17[b]	9.00	153.00
	Ties	33[c]		
	Total	50		

a. E2 < E1

b.E2 > E1

c. E2 = E1

Test Statistics[b]

	E2 - E1
Z	-3.879[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 13 E3 – E2	Negative Ranks	15[a]	8.00	120.00
	Positive Ranks	0[b]	.00	.00
	Ties	35[c]		
	Total	50		

a. E3 < E2

b. E3 > E2

c. E3 = E2

Test Statistics[b]

	E3 - E2
Z	-3.626[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Question 13 E4 – E3	Negative Ranks	22[a]	12.14	267.00
	Positive Ranks	1[b]	9.00	9.00
	Ties	27[c]		
	Total	50		

a. E4 < E3

b. E4 > E3

c. E4 = E3

Test Statistics[b]

	E4 - E3
Z	-4.126[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

Total scores of the 13 question of the questionnaire of the 50 enterprises over the four evaluations

Enterprise	E1	E2	E3	E4	Enterprise	E1	E2	E3	E4
1	48	52	40	25	**26**	40	46	40	39
2	44	49	45	43	**27**	42	47	44	39
3	44	47	48	43	**28**	38	43	39	38
4	43	46	38	38	**29**	41	46	47	39
5	48	50	46	43	**30**	41	46	39	38
6	49	52	47	41	**31**	38	45	39	38
7	44	47	46	43	**32**	44	48	44	41
8	50	51	46	40	**33**	45	46	40	39
9	48	55	48	43	**34**	50	50	45	38
10	46	53	48	41	**35**	45	47	39	39
11	41	44	42	41	**36**	43	46	43	39
12	32	43	43	38	**37**	38	42	41	40
13	39	44	45	43	**38**	40	44	38	35
14	38	46	40	39	**39**	42	43	41	35
15	44	49	47	41	**40**	43	48	45	41
16	43	47	43	39	**41**	55	57	35	41
17	45	48	41	38	**42**	45	47	40	43
18	42	48	41	40	**43**	50	51	44	39
19	45	46	45	39	**44**	43	48	41	38
20	46	49	43	41	**45**	38	40	39	38
21	47	52	47	43	**46**	52	55	47	41
22	47	51	47	41	**47**	48	53	45	40
23	38	45	43	41	**48**	44	51	41	38
24	39	44	44	41	**49**	44	43	41	42
25	36	39	35	34	**50**	47	46	43	40
					Total	**2182**	**2375**	**2148**	**1977**

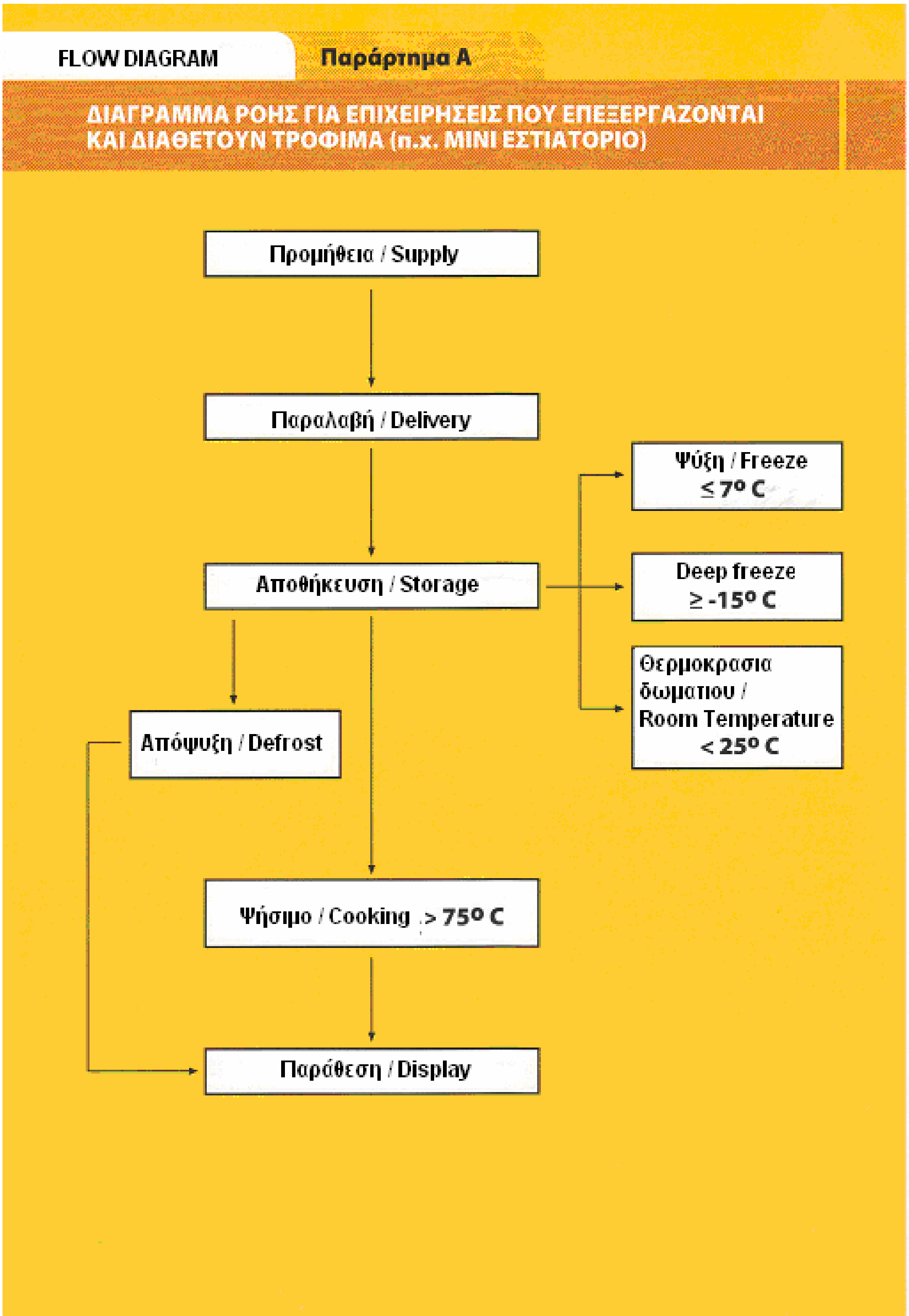
Appendix E:

Appendix E1: HACCP Plan

Πίνακας ελέγχου HACCP - Παρακολούθηση Κρίσιμων Σημείων Ελέγχου (Κ.Σ.Ε.)

Α.Α	Κ.Σ.Ε.	Κρίσιμο Όριο	Παρακολούθηση			Διορθωτική ενέργεια
			Διαδικασία	Συχνότητα	Υπευθυνότητα	
1	Αποθήκευση πρώτων υλών στο ψυγείο συντήρησης ή στην κατάψυξη (Μ)	≤7ºC ≥-15ºC	Έλεγχος θερμοκρασίας ψυγείου συντήρησης ή κατάψυξης	2 - 3 φορές την ημέρα	Αποθηκάριος ή υπεύθυνος παραγωγής	Επιδιόρθωση ψυγείου. Μετακίνηση τροφίμων σε άλλο ψυγείο. Καταστροφή τροφίμων
2	Ψήσιμο τροφίμων (Μ)	Εσωτερική θερμοκρασία πέραν των 75ºC	Έλεγχος και καταγραφή θερμοκρασίας μετά το ψήσιμο	Κατά διαστήματα	Υπεύθυνος παραγωγής	Επαναψήσιμο. Αλλαγή προγράμματος ψησίματος ή βρασμού
3	Αποθήκευση ετοίμων τροφίμων σε συντήρηση ή κατάψυξη(Μ)	≤7ºC ≥-15ºC	Έλεγχος και καταγραφή θερμοκρασίας	2 - 3 φορές την ημέρα	Υπεύθυνος παραγωγής	Επιδιόρθωση ψυγείου. Μετακίνηση τροφίμων σε άλλο ψυγείο. Καταστροφή τροφίμων
4	Ξαναζέσταμα τροφίμων	Εσωτερική θερμοκρασία πέραν των 75ºC	Έλεγχος και καταγραφή θερμοκρασίας μετά το ξαναζέσταμα	Κατά διαστήματα	Υπεύθυνος παραγωγής	Ικανοποιητικό ξαναζέσταμα
5	Ζεστή διατήρηση τροφίμων	>63ºC	Έλεγχος και καταγραφή θερμοκρασίας	2 φορές	Υπεύθυνος παραγωγής	Ρύθμιση θερμοκρασίας θερμοτράπεζας (μπεν μαρί)
	C.C.P	Critical Limit	Monitoring Procedures			Corrective Action

Appendix E2: Flow Diagrams



Appendix F: Sample Chronology

Katerina Traditional sweet

Level	Visit	Dates	Activity
1	1	15/10/05	Informative meeting: information regarding the procedures of the implementation of HACCP system and the research,
	2	31/10/05	Diagnostic audit and indications for changes / Data collection
2	3	15/11/05	Training on PRPs
	4	13/01/06	Training on PRPs
	5	13/03/06	Training on PRPs
	6	25/04/06	Data collection
3	7	10/05/06	Coaching on HACCP principals / enterprises provided with guidelines
	8	10/07/06	Coaching and answering questions on HACCP principles
4	9	10/08/06	More rigorous overview of HACCP principles
	10	10/10/06	Development of HACCP plan based on HACCP principles according to Codex Alimentarious / enterprises provided with guidelines
	11	11/12/06	Presentation and explanation of HACCP plan to personnel and its implementation. Assistance on legislation concerning HACCP plan
	12	23/01/07	Data collection
5	13	07/02/07	Recommendations and assistance on barriers during the implementation of HACCP plan
	14	07/04/07	Advice on record keeping
6	15	07/05/07	Training on ISO 9001 and management system
	16	07/07/07	Training on CYS 244 standard
	17	07/09/07	Training on guidelines and application of CYS 244 standard
	18	19/10/07	Data collection
7	19	02/11/07	Certification
	20	03/12/07	Presentation and explanation of ISO 22000 and its applications
8	21	04/02/08	Coaching on the changes of the system according to ISO22000. Advice on record keeping and barriers faced during the application of ISO 22000
	22	04/04/08	Data collection

Appendix G: Basic Information of the 50 SMEs

Enterprise	No. of Employees	Type of Enterprise
1	10	Bakery
2	8	Restaurant
3	5	Fast Food
4	12	Restaurant
5	9	Restaurant
6	6	Bakery
7	3	Fast Food
8	9	Restaurant
9	5	Fast Food
10	11	Restaurant
11	13	Restaurant
12	15	Restaurant
13	17	Restaurant
14	11	Restaurant
15	8	Bakery
16	16	Restaurant
17	3	Butchery
18	3	Fast Food
19	9	Bakery
20	3	Butchery
21	6	Bakery
22	5	Fast Food
23	19	Restaurant
24	8	Bakery
25	6	Bakery

26	9	Bakery
27	3	Butchery
28	2	Butchery
29	5	Fast Food
30	5	Bakery
31	8	Bakery
32	18	Restaurant
33	21	Restaurant
34	17	Restaurant
35	19	Restaurant
36	3	Butchery
37	6	Bakery
38	10	Bakery
39	5	Fast Food
40	4	Fast Food
41	5	Fast Food
42	3	Butchery
43	15	Restaurant
44	9	Butchery
45	19	Restaurant
46	5	Bakery
47	3	Bakery
48	2	Butchery
49	7	Bakery
50	11	Restaurant